UNDERSTANDING E-WASTE REVERSE SUPPLY CHAIN AND FORMALIZATION OF INFORMAL E-WASTE PROCESSORS: A QUALITATIVE CASE STUDY

By

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This is study my doctoral dissertation in the Production and Operations Management Area at IIM Bangalore. I defended the thesis on September 17, 2018. Going forward, this document would be revised based on your feedback and suggestions.

"The empirical basis of objective science has thus nothing 'absolute' about it. Science does not rest upon solid bedrock. The bold structure of its theories rises, as it were, above a swamp. It is like a building erected on piles. The piles are driven down from above into the swamp, but not down to any natural or 'given' base; and if we stop driving the piles deeper, it is not because we have reached firm ground. We simply stop when we are satisfied that the piles are firm enough to carry the structure, at least for the time being." – Karl Popper[1].

"The result of philosophical exploration is not the end of inquiry in a settled opinion, but a mind resting more comfortably among many possibilities, or else the reframing of the question, and a new inquiry." - Kwame Anthony Appiah[2].

[1] Popper, K. (1959). *The Logic of Scientific Discovery*. New York: Routledge.
[2] Appiah, K. A. (2003). *Thinking It Through: An Introduction to Contemporary Philosophy*. New York: Oxford University Press.

I thank the respondents (90+ market participants in the e-waste recycling industry) for taking out their time and sharing their knowledge. I owe them a debt of gratitude. This study is dedicated to them (in particular, participants in the informal economy).

ABSTRACT

India is facing serious threats to its environment due to inappropriate management of discarded electrical and electronic products (e-waste). E-waste comprises products such as computers, mobile phones, television sets, photocopiers, washing machines, refrigerators, etc. These are primarily made of plastic, glass, metal, and toxic substances. E-waste processors are firms that create value from e-waste through reuse, refurbish, cannibalization, and metal recovery operations. When e-waste is processed and disposed unscientifically to create value (for example, recovering copper, gold, silver, etc.), toxic substances (lead, cadmium, etc.) are emitted into the surrounding environment, thereby polluting air, soil, and ground water. This affects public health and environment, creating negative environmental externalities. Reducing these negative externalities has become a top priority in India's policy circles.

E-waste processors in the informal economy (Informal Processors) are not authorized or recognized by the Government and do not pay taxes. Such firms are engaged in unscientific processing and disposal (with low set-up and operating costs) of e-waste, with negative consequences to public health and environment. E-waste processors in the formal economy (Formal Processors) are authorized and recognized by the Government and pay taxes. Such firms are engaged in scientific processing and disposal (better technology with higher costs) of e-waste, without harming public health and environment.

India enacted **Product Take-Back Legislation** for e-waste (specific products in information technology/telecom and consumer electronics) in 2012, mandating manufacturers of electrical and electronic products to collect and process their e-waste. This is called E-waste Management and Handling Rules (EMHR), and is intended to minimize negative environmental externalities by reducing unscientific processing and disposal. EMHR also mandated that e-waste processing should be done only by Formal Processors. EMHR is based on the concept of Extended Producer Responsibility, followed in developed market contexts (like USA, EU, Japan), and do not incorporate the *unique issues* of emerging market contexts (like India, Africa, Brazil, China). Emerging markets are characterized by a history of poor compliance with environmental legislations, significant presence of e-waste processors in the informal economy, and difficulties in identifying manufacturers due to the presence of non-branded/counterfeit products.

To resolve some of these unique issues prevalent in emerging market contexts, this dissertation studies the following question within the context of India: *How can e-waste processors in the informal economy be incentivized to adopt safe, scientific methods and become a part of the formal economy?* To develop such incentive schemes, one needs to **understand** the following contextual phenomena:

(1) *Formalization of Informal Processors*: How did some of the Informal Processors become Formal Processors (i.e. Government authorized)? What operational challenges did they face while transitioning from informal to formal?

(2) *Structure of Reverse Supply Chain*: What are the sequence of processes involved in transforming e-waste into revenue generating recyclables? Who are the stakeholders involved in this transformation process and how do they transact?

Given the lack of adequate knowledge in published academic literature, an appropriate methodology for this understanding is **qualitative case study research**. This methodology uses a variety of data sources and investigates a contemporary phenomenon (formalization, reverse supply chain) in-depth within its real-life context (India). We followed the case study research approach advocated by Robert Yin. The case study research design consisted of specifying initial research questions to understand contextual phenomena (formalization, reverse supply chain), developing conceptual framework and propositions, deciding unit of analysis, collecting data from primary and secondary sources (spanning 2 years and interviewing 49 stakeholders across the reverse supply chain), evaluating propositions from field evidence using pattern matching technique, revising propositions and discussing emergent themes. These revised propositions and emergent themes led to interesting findings. The key findings are as follows:

(1) Merely formalizing Informal Processors, as per EMHR, does not reduce negative externalities and consequently does not solve the e-waste problem.

(2) The simplistic assumption that formalization would help Informal Processors to process more e-waste efficiently due to scale economies, is falsified through this field study.

(3) It is important to recognize the contingent characteristics of Informal Processors to understand formalization and e-waste Reverse Supply Chain.

(4) Operational configuration (low cost, high flexibility) of Informal Processors is, surprisingly, aligned with the nature of e-waste processing industry (characterized by erratic supply, heterogeneous products with uncertain yield, influence of market forces).

E-waste Reverse Supply Chain is market-driven i.e. various market forces (ex: technological change, international commodity markets, economic value of products) influence the flow of products and prices in this reverse supply chain. In the current way of formalization, this alignment is lost when Informal Processors become Formal Processors.

(5) E-waste Reverse Supply Chain is path dependent i.e. the existing supply chain is a function of several historical events (centuries-old scrap metal recycling, ancient metallurgical knowledge, significant presence of informal economy in every industry).

Product Take-Back Legislation, which is adopted from developed markets with strong institutions and small informal economy, relies on costly enforcement (due to command-and-control approach) and criminalizes the informal economy. Our findings suggest that this legislation *may not be appropriate* for emerging markets (like India) with weak institutions and large presence of informal economy in every economic activity. Rather than discussing about effective enforcement, monitoring, and compliance of product take-back legislations, we need to discuss alternate policies. Through this research we provide policy recommendations to incentivize Informal Processors as follows:

- ✓ Set-up Recycling Parks to provide infrastructure, eco-system, and ease-of-doing business for processors in the informal economy.
- ✓ Facilitate markets to function by encouraging the industry of commodities (glass, metals, plastic, etc.) recycling and precious metal refining (recovery of precious metals from e-waste).
- ✓ Provide Industry Status (i.e. Government accords an official status of industry) for the e-waste processing industry. This would enable the following: borrow loans from financial institutions at low interest, tax benefits, and reduced cost of borrowing.

By outlining these implications for e-waste policy, we do not claim that our recommendations are frictionless. Adopting such market-based approaches comes with its own set of challenges. Our contribution is to *reframe* the e-waste problem in a different dimension so that efforts to improve policy can be channeled in ways that are aligned with the nature of e-waste processing industry.

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List of Terms & Abbreviations

Terms	Abbreviations/Meaning
PCBs/boards	Printed Circuit Boards that are found in every electronic product
SPCB	State Pollution Control Board
CPCB	Central Pollution Control Board
MoEF	Ministry of Environment & Forests
KSPCB	Karnataka State Pollution Control Board
TSDF	Treatment, Storage, and Disposal Facility
MNCs	Multi-National Companies
VAT	Value Added Tax
SSI	Small Scale Industry
MSME	Micro, Small, and Medium Enterprise
PPE	Personal Protective Equipment (ex: gloves, masks, goggles, helmet, etc.)
KIADB	Karnataka Industrial Areas Development Board
MSTC	Metal Scrap Trading Corporation
DPR	Detailed Project Report
EMHR	E-waste Management & Handling Rules. This was enacted in May 2011, effective from May 2012, and superseded in 2016.
PCM	Product or Components Manufacturer i.e. a firm manufacturing a final product (e.g., watches, automobiles, computers) or components (e.g., autocomponents, printed circuit boards, microchips).
Manufacturer	Denotes the manufacturer of final product (electrical and electronic only). For example, Dell, Lenovo, Apple, etc. are manufacturers.
SEZ	Special Economic Zone
Dismantling	This means e-waste is disassembled and segregated (or separated) into components containing plastics, glass, and metals.
Recycling	This means metal recovery i.e. extracting precious metals from printed circuit boards.
Material/Scrap	This means e-waste/electrical/electronic scrap. E-waste processors use this label i.e. “material”, “scrap” rather using the label “e-waste”.
LME	London Metal Exchange

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Chapter 1: Introduction

1.1 Motivation for the study

Products that have electrical, electronic components are called electronic waste (e-waste), once they are no longer desired or can no longer be used by their consumer (StEP, 2014; Boone & Ganeshan, 2012). E-waste includes products such as computers, laptops, mobile phones, televisions, photocopiers, washing machines, refrigerators, toys, toasters, etc.[1]. *E-waste is estimated to be one of the fastest growing waste streams in the world, growing at three times the rate of municipal waste* (UNEP, 2007). Global volume of e-waste generation is expected to reach 130 million tonne in 2018 at a Compounded Annual Growth Rate (CAGR) of 17% (Assocham-cKinetics, 2016). E-waste generation in India, would increase by nearly three times, from the existing 18 lakh MT[2] to 52 lakh MT per annum by 2020 at a 30% CAGR (Assocham-cKinetics, 2016).

E-waste is primarily composed of plastic, glass, metals, and toxic substances (Boone & Ganeshan, 2012). When processed in unsafe conditions to recover valuable materials (copper, gold, silver, etc.) or disposed into unscientific landfills, toxic substances (lead, cadmium, arsenic, etc.) are emitted into the surrounding environment. This creates negative environmental externalities i.e. negatively impacts the environment (air, water, soil, etc.) and human health. Two examples to illustrate this, are as follows: (1) burning printed circuit boards on a stove, without using any personal protective equipment, to recover solder or disassemble components releases lead, dioxins, cadmium, etc. (2) burning cables to take out copper, releases dioxins (Sepulveda et al., 2010). Such operations are done by processors in the informal economy. *E-waste processors in informal economy (Informal Processors) consists of groups of workers who engage in such rudimentary processing operations (with low set-up and operating costs) for their livelihood, with negative consequences to health and environment vis-a-vis the Formal Processors (Government authorized) with better technology and higher costs* (Lundgren, 2012). More than 90% of e-waste is processed in the informal economy in developing countries like India, China, Kenya, Bangladesh, etc. (Lundgren, 2012). *India's e-waste processing market, recovering valuable materials, is worth $1,900 million* (Frost & Sullivan, 2012). This is expected to reach $5 billion by 2020 (MarketsandMarkets, 2015). This

[1] Source: http://www.step-initiative.org/what-is-ewaste.html, accessed on February 8, 2017.
[2] MT means metric tonne. 1 MT = 1,000 kg

is significant, considering the global e-waste processing market expected to be worth $50 billion by 2020 (Allied Market Research, 2015).

Scholars specialized in toxicology have studied the negative effects of informal e-waste processing. A review article reported very high levels (more than permissible limits) of lead concentration, brominated flame retardants in air, soil, water and sediments in informal e-waste processing areas of India and China (Sepulveda et al., 2010). In another study, significantly higher levels of brominated flame retardants were found in human breast milk based on samples collected in areas surrounding municipal dump sites in Kolkata, Bangalore, and Chennai (Devanathan et al., 2012). Brominated flame retardants are used in electrical and electronic products for its flame-retardant properties (Devanathan et al., 2012). The toxicology study conducted by Toxics Link in Mondoli and Loni areas around Delhi, where there are more than 100 informal e-waste processing units, reported high levels (more than permissible limits) of lead, cadmium, nickel, mercury, hexavalent chromium, and zinc in soil and water samples (Toxics Link, 2014). These metals and chemical compounds are known to cause neurological disorders, lung cancer, and malfunctioning of vital organs in the human body (Sepulveda et al., 2010; Toxics Link, 2014). In a review paper that studied the relation between exposure to informal e-waste processing and adverse health effects, a significant relation was reported between people living in e-waste processing towns or working in e-waste and adverse health effects (Grant et al., 2013). The health effects were changes in thyroid functioning, DNA damage (i.e. impact on cellular functioning), adverse effects in pregnancy and newborn behavior, reduced lung functioning, etc. (Grant et al., 2013). These adverse health effects directly impact the economic productivity, at the country level. For example, *the loss in economic productivity in India, due to childhood lead exposure (higher than permissible levels) is estimated to be $236 billion* (Attina & Trasande, 2013). Hence, there is a need for appropriate management of e-waste to mitigate these negative externalities (Boone & Ganeshan, 2012).

Government interventions through public policies are justified due to public goods like air, water, health affected by these negative externalities. *The most popular Government intervention is to hold manufacturers responsible (operationally, financially, or both) for the environmental impact of their products through a Product Take-Back Legislation* (Atasu & Wassenhove, 2012; Lifset et al., 2013). This legislation is intended to minimize the negative externalities by reducing the amount of e-waste sent to landfills, and to provide manufacturers with incentives to design greener products. The concept of Product Take-Back Legislation is a

specific type of Extended Producer Responsibility (Lindhqvist & Lidgren, 1990; Lindhqvist, 2000). The philosophy behind Extended Producer Responsibility (EPR) is as follows: instead of holding the end-consumers responsible for waste disposal, pass the responsibility of waste disposal to the producers (Fishbein, 1998). This implies mandating the producers to be responsible for the entire product lifecycle including taking it back from end-consumers, recycling, and safe disposal. EPR originally appeared in a report prepared by Thomas Lindhqvist to the Swedish Ministry of Environment in 1990. Later, in 2000, Lindhqvist developed this concept as his doctoral dissertation.

This concept of passing the responsibility of product disposal to manufacturers was immediately assimilated by European Union (EU) and Product Take-Back Legislations were enacted in packaging, cars, batteries, tires, e-waste, etc. The Directive on Waste Electrical and Electronic equipment (WEEE Directive) was put in place by EU in 2003[3]. WEEE Directive imposed collection, recovery, and recycling targets for 10 categories of e-waste on all EU member countries. Slowly, other developed markets like USA, Japan, etc. started to copy WEEE Directive as the template for drafting e-waste product take-back legislations (Atasu & Wassenhove, 2012). But, the way in which this legislation was implemented varied i.e. the implementation models differed. In an Individual Producer Responsibility (IPR) model, prevalent in Japan, each manufacturer collects and recycles her products only. But, in a Collective Producer Responsibility (CPR) model, products of all manufacturers are collected and recycled jointly. In a monopolistic CPR system, prevalent in Switzerland, Belgium, Netherlands, Sweden, California, etc., non-profit organizations collect e-waste and allocates them to Government authorized processors. The costs for these operations are borne by manufacturers or consumers or shared between the two. Competitive CPR systems, prevalent in France, Ireland, etc. permit manufacturers to establish partnerships with other manufacturers and Government authorized processors for collecting and recycling operations. The financing mechanisms and other details like collection and recycling targets, types of e-waste product categories covered, etc. differ between various implementation models. A detailed description of the same can be found in Atasu & Wassenhove (2012). Several implementation models of product take-back legislation being practiced in most developed markets (22 states in USA, member countries of EU, etc.) are being introduced in emerging markets like China, India.

[3] Source: http://ec.europa.eu/environment/waste/weee/index_en.htm, accessed on February 8, 2017.

Recently, Operations Management (OM) scholars have begun to analyze various implementation models of e-waste product take-back legislation in order to improve stakeholders' compliance and protect the environment (Atasu & Wassenhove, 2012). Stakeholders' incentives to comply with legislation vary for different implementation models. Unless the stakeholders' incentives are aligned, the implementation models will not achieve the desired objective of legislation (Atasu & Wassenhove, 2012). This stream of OM literature studies particular country contexts (market contexts) to suggest improvements in implementation models within respective contexts.

Currently, India also has a product take-back legislation for e-waste. This is called E-waste Management & Handling Rules (EMHR). This was first enacted in 2011 and superseded in 2016[4]. In India, the Government has provided freedom to manufacturers to decide on an appropriate implementation model. This topic of e-waste management and take-back legislation is also discussed in the Indian Parliament (Lok Sabha and Rajya Sabha). For example, Dr. V.K. Agnihotri, Former Secretary-General of Rajya Sabha, said in June 2011:

> "The widespread use of electronic items has made communication easier, boosted business activities and created employment opportunities. However, along with the benefits, it has brought into focus many challenges, like the rising problem of e-waste, that have to be boldly dealt with by society. In the current scenario, it is always possible that human health and environment would be drastically endangered if concerted legislations and actions were not taken for efficient management and disposal of e-waste." (Rajya Sabha, 2011).

Questions asked in the Parliament, by citizens' representatives to the Ministry of Environment and Forests (MoEF) illustrates the national importance of this topic. A few representative questions are listed below in Table 1.

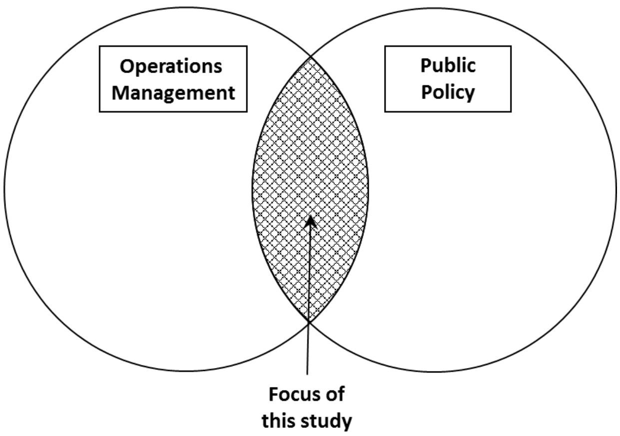
[4] EMHR 2011 and 2016 are included in the Appendix 6 and Appendix 7, respectively.

Table 1: Questions on e-waste management asked in the Indian Parliament[5]

Date of question	Question
August 21, 2012	"The system and rules that govern recycling of such e-waste to control any kind of harmful effects on the people in general, and children and women, in particular; and Whether certain guidelines have been framed and circulated to ensure that all such rules are followed in letter and spirit to control any of its harmful effects on the public in general?"
February 10, 2014	"The amount of electronic waste being generated every year in the country and the steps taken by the Government to reduce the e-waste pollution? The efforts being made by the Government to raise the capacity of recycling of e-waste along with the success achieved by the Government in this regard? "
July 16, 2014	"Whether a large number of industrial units and public enterprises are reportedly violating the rules governing e-waste management and if so, the details thereof along with the monitoring mechanism put in place in this regard and the action taken against the erring industries; The steps taken by the Government for effective e-waste management in the country?"

These conversations within the respective communities of OM scholars and policy makers reveal that Product Take-Back Legislation for E-waste and their implementation models are worthy of serious academic study that is relevant to public policy. Thus, this dissertation attempts to integrate OM and Public Policy within the context of e-waste and take-back legislation (Joglekar et al., 2016). This focus is illustrated in Figure 1.

Figure 1: Focal area of this study



[5] Source: http://164.100.47.4/newrsquestion/ShowQn.aspx, accessed on February 8, 2017.
Source: http://164.100.47.132/questionslist/MyFolder/10.02.144034LS.pdf, accessed on July 24, 2014.
Source: http://164.100.47.132/questionslist/MyFolder/16072014.pdf, accessed on July 24, 2014.

1.2 Research questions and findings

The objective of this study is to find an appropriate implementation model or public policy for India (an emerging market) to manage e-waste. India's product take-back legislation (EMHR[6]) mandates all informal processors to become part of the formal economy by obtaining Government authorization. Given that 90% of the e-waste is processed in the informal economy using rudimentary, unscientific, and unsafe methods, the following overarching question is worth studying: *How can e-waste processors in the informal economy be incentivized to adopt safe, scientific methods and become a part of the formal economy?* To answer this question, one needs to understand the following phenomenon:

- ✓ *Formalization of Informal Processors*: How did some of the Informal Processors become formal (i.e. Government authorized)? i.e. What was their formalization process? What operational challenges did they face while transforming from informal to formal?

- ✓ *Structure of E-waste Reverse Supply Chain*: What are the sequence of processes involved in transforming e-waste into revenue generating recyclables? Who are the stakeholders involved in this transformation process and how do they transact?

Thus, the focus of this research study is to understand the transformation process of how Informal Processors become Formal Processors (formalization) and how e-waste is transformed into revenue generating recyclables (reverse supply chain). This understanding is achieved using qualitative case study[7], spanning 2 years of fieldwork by interviewing 49 stakeholders in the e-waste processing industry. In this dissertation, we have used Yin's approach to qualitative case study (Yin, 2009)[8]. Using qualitative case study methodology for in-depth understanding of a phenomenon and suggesting appropriate public policy (based on this in-depth understanding) is also suggested by scholars in OM and public policy (Atasu & Wassenhove, 2012; Lin 1998). From the qualitative case study, we find the following:

a) Merely formalizing Informal Processors, as per EMHR, does not reduce negative externalities and consequently does not solve the e-waste problem.

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[6] Unless specified otherwise, EMHR denotes the legislation enacted in 2011.
[7] Terms like qualitative case study, fieldwork, field study, and field research are used synonymously.
[8] Yin's approach was chosen after a careful study of various approaches. This is described in Chapter 3.

b) The simplistic assumption that formalization would help Informal Processors to process more e-waste efficiently due to scale economies, is falsified through this field study.
c) It is important to recognize the contingent characteristics of Informal Processors to understand formalization and e-waste Reverse Supply Chain.
d) Operational configuration (low cost, high flexibility) of Informal Processors is aligned with the nature of e-waste processing industry. In the current way of formalization, this alignment is lost when Informal Processors become Formal Processors.
e) E-waste Reverse Supply Chain is market-driven i.e. various market forces (ex: technological change, international commodity markets) influence the flow of products and prices in this reverse supply chain.
f) E-waste Reverse Supply Chain has developed from centuries-old scrap metal recycling supply chain (path dependence).

Extant theorization on e-waste product take-back legislation has focused on developed markets. This study, focused on an emerging market (India) has brought attention to several concepts/moderating factors ignored in the extant literature. Take-Back Legislation (adopted from developed markets with strong institutions and small informal economy) that relies on costly enforcement (due to command-and-control approach) and criminalizes the informal economy, may not be appropriate for emerging markets (like India) with weak institutions and large presence of informal economy in every economic activity.

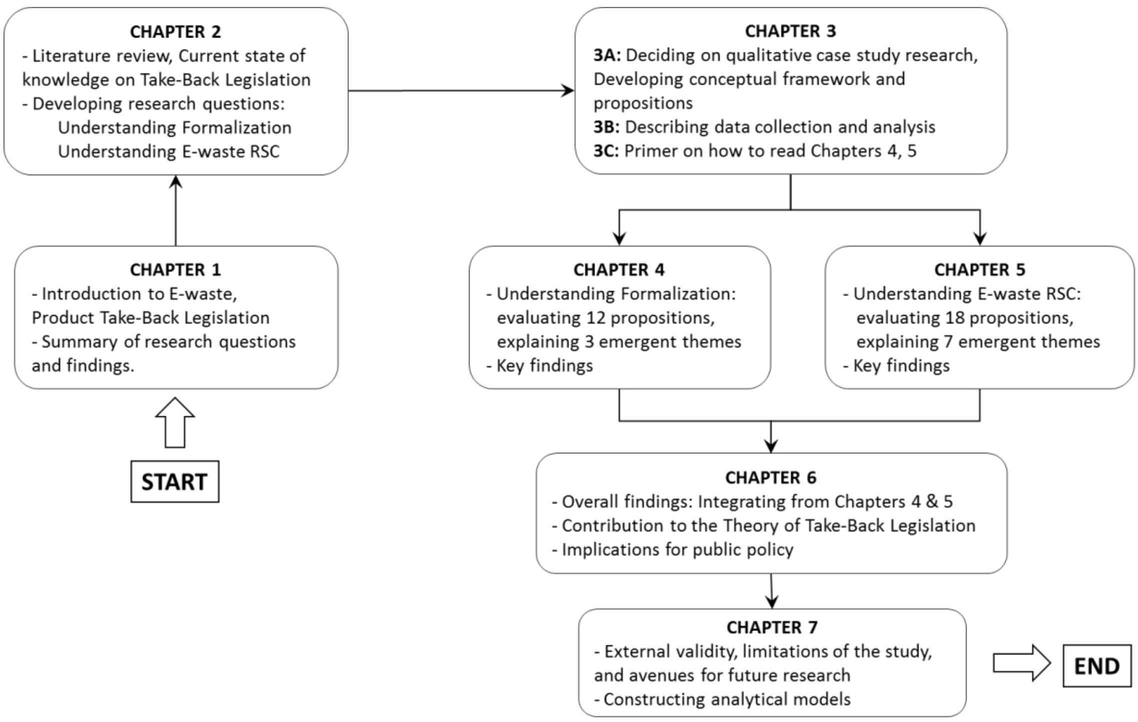
1.3 Organization of chapters

This chapter (Chapter 1) introduced the topic of this research study (i.e. dissertation). This includes study motivation, research questions, study findings, and contribution to theory. A review of the relevant literature is provided in Chapter 2. This includes research done by OM scholars and the need to study emerging markets (India) to extend theorization on this topic. The research questions and its rationale are articulated in Chapter 2. In Chapter 3, research design for the study is developed. This is divided into three parts: 3A, 3B, and 3C. Chapter 3A consists of deciding an appropriate methodology (qualitative case study) based on the nature of research questions and developing a conceptual framework with propositions to guide data collection and analysis. Totally, 30 propositions are developed based on the available literature. <u>*12 propositions are developed for Understanding Formalization and 18 propositions are developed for Understanding the Structure of Reverse Supply Chain*</u>. Chapter 3B consists of

developing questionnaire, deciding the sample frame, and detailed description of data collection and analysis. The end-to-end process of how the qualitative case study was conducted is explained. Steps taken to ensure reliability and validity of the study are also explained. Chapter 3C gives a primer on how to read Chapters 4 and 5.

In Chapter 4, 12 propositions developed for Understanding Formalization of Informal Processors are evaluated. Three emergent themes revealed from field evidence are also explained. In Chapter 5, 18 propositions developed for Understanding Reverse Supply Chain are evaluated. Seven emergent themes revealed from field evidence are also explained. Findings of this study, contributions to theory, and implications for public policy are discussed in Chapter 6. The last chapter (Chapter 7), explains external validity (i.e. generalizability), limitations of the study, and avenues for future research. As part of future research, in Section 7.3, we also show the potential to construct stylized analytical models based on evidence obtained from this qualitative field study. Organization of these chapters are illustrated below in Figure 2.

Figure 2: Organization of chapters in the dissertation



Chapter 2: Literature Review

In this chapter, we[9] review the literature on e-waste and take-back legislation. We delineate the questions asked by OM scholars, identify the research gap, and position this research study within the gap. A pilot study, conducted to strengthen this research gap, is also explained. Finally, we develop research questions that contributes to the existing OM literature on e-waste take-back legislation.

2.1 Review of literature in other disciplines

Scholars in sociology, economics, and management have studied this topic (i.e. e-waste management and take-back legislation) through their respective disciplinary lens. Key questions studied by scholars in sociology and allied disciplines (like intersection of geography and society) are as follows: What struggles are borne by the informal processors and how do they make a living? How are informal e-waste processors excluded by the mainstream economy while designing legislations? How can such legislations be made inclusive? How informal e-waste processors are exploited due to poor enforcement of law? How do power relations between various stakeholders exploit informal processors? (Smith et al., 2006; Bhaskar & Chikarmane, 2012; Gidwani & Reddy, 2011; Chikarmane, 2012). The dominant methodology used by this set of scholars is qualitative research and includes ethnography, case study research. Key questions studied by scholars in environmental economics and public policy are as follows: What is the process of designing legislation i.e. the entire process from recognizing the need for Government intervention to a concrete legislation? What are the theoretical conditions that lead to socially optimal level of incentives (social welfare maximizing) for manufacturers, consumers, processors in the context of take-back legislation? Accordingly, what implementation models would be theoretically efficient? (See Walls (2003) for a review of this stream of literature). The dominant methodology used by this set of scholars is stylized analytical modelling.

2.2 Review of OM literature

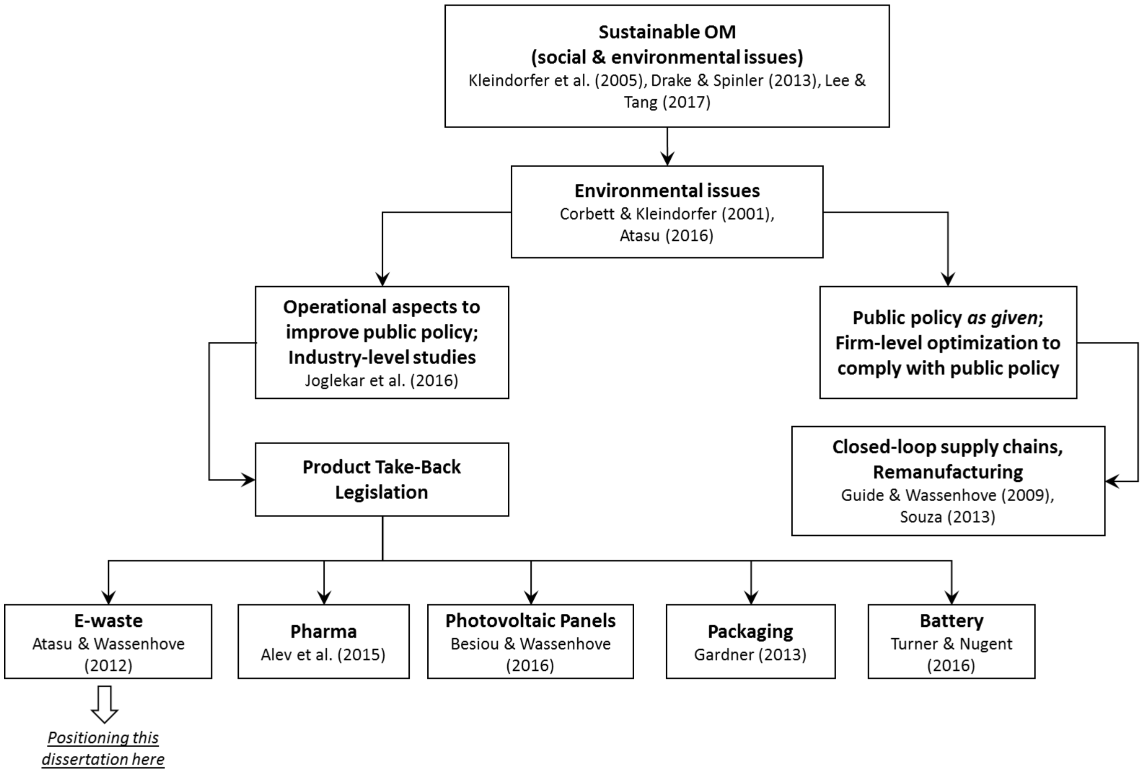
[9] The initial draft of this dissertation was written using "I". Based on the feedback from dissertation advisory committee, "I" was changed to "we". Throughout this dissertation, "we" is used. However, this does not denote that dissertation was done by a group. This dissertation is an independent/sole work of the doctoral student.

In the previous decade, scholars in management discipline have called for more relevant academic research that includes public policy as a central part (Rynes & Shapiro, 2005; D'Aunno, 2005). For example, Hitt (2005) explained how management scholars can do systematic research and add value to public policy in varied topics like unemployment, corporate governance, and international trade. Responding to these calls, OM scholars have begun studying various topics that includes public policy as a central part of their research. Take-Back Legislation for E-waste is one among such topics (Atasu et al., 2009). This topic is a part of the broad area of Sustainable Operations Management that studies environmental and social issues from an OM perspective (Kleindorfer et al., 2005; Drake & Spinler, 2013; Lee & Tang, 2017). The uniqueness of OM perspective to the topic of e-waste take-back legislation is explained by Atasu & Wassenhove (2012) as follows:

> "Understanding how take-back legislation is translated into practical laws, how it is operated, and how it affects producers' operational decisions is crucially important for coming up with recommendations to policy makers and economic stakeholders. A high-level economic analysis may not be able to answer these questions. A micro-level analysis, however, can not only help identify superior implementation choices, but also shed light on how existing and potentially upcoming product take-back legislation affects operational decisions in production systems […] Therefore, many pressing issues related to product take-back legislation can be answered by a systematic operational look."

OM scholars focus their efforts to understand the challenges of operationalizing take-back legislation (ex: impact on industry competitiveness, fairness concerns, product design improvements, etc.) and other stakeholders' perspectives like manufacturer profits, consumer surplus, recycler profits, etc. The key objective is to understand the micro-level details which are typically overlooked by other disciplines. The big question asked by OM scholars is *How should Governments design implementation models for e-waste product take-back legislation by anticipating stakeholders' responses (particularly manufacturers) and other operational issues?* (Atasu & Wassenhove, 2012). The dissertation is positioned in this stream of literature that investigates answers to this big question. A conceptual framework illustrating the positioning of this dissertation can be found in Figure 3. In this figure, we have outlined only the key papers.

Figure 3: Positioning this dissertation within the literature



It can be noted from the above figure that, different streams of literature focusing on different industry contexts have emerged i.e. e-waste, pharma, photovoltaic panels, battery, etc. This is because industry dynamics differ. For example, e-waste is durable, while pharma is consumable (Alev et al., 2015). Findings from one industry context (say, e-waste) need not be generalizable to other industry contexts (say, photovoltaic panels or battery). The broad questions studied, in this stream of literature on e-waste, based on various market (country) contexts, are as follows: How to set collection and recycling targets? What is the impact of various implementation models on product design improvements (ex: design for recyclability or reuse, design for environment, etc.)? What is the impact of various implementation models on stakeholders' incentives (including costs, fairness, and profits)? How to design take-back legislation in the presence of Informal Processers? Key questions studied by OM scholars are summarized in Table 2 below.

Table 2: Key questions studied by OM scholars

Market context	Questions	Methodology
EU's WEEE Directive 2003	What should be an efficient (economically and environmentally) implementation model? (Atasu et al., 2009)	Stylized analytical modeling
California's Advanced Recovery Fee model; Japan's IPR model	What is the impact of fee-upon-sale and fee-upon-disposal models on frequency of new product introduction? (Plambeck and Wang, 2009)	Stylized analytical modeling
CPR model of WEEE Directive in countries like Belgium, Sweden, and Netherlands; Japan's IPR model	What is the impact of IPR/CPR models on product design, manufacturer profits, and consumer surplus? (Atasu and Subramanian, 2012)	Stylized analytical modeling
Monopolistic model in Belgium, Sweden, and Netherlands; Competitive model in Germany and Austria	What is the impact of monopolistic and competitive models on recycling fees, product prices, manufacturer, and recycler profits? (Toyasaki et al., 2010)	Stylized analytical modeling
Implementation models in Minnesota and Wisconsin	What is the impact of disposal-fee model on manufacturers' recovery decision? (Ozdemir et al., 2012)	Stylized analytical modeling
Government-operated model in Taiwan, China; Manufacturer-operated model in Michigan and majority of EU countries.	What are stakeholders' perspectives on government versus manufacturer operated implementation models? (Atasu et al., 2013)	Stylized analytical modeling
Greece	What should be the implementation model in the presence of Informal Processors? (Besiou et al., 2012)	System Dynamics
Washington	What are the operational challenges to implement product take-back legislation? (Gui et al., 2013)	Qualitative Case Study
Minnesota	What are the operational issues in implementing Minnesota Electronics Recycling Act? (Alev et al., 2015)	Qualitative Case Study

It can be inferred from the above table that OM scholars have focused on developed market (country) contexts. Public policy in developed markets have followed a *command-and-control* approach, where Government mandates (command) all stakeholders to act according to what is specified in the legislation. If the stakeholders do not comply, they are punished in the form of fines, cancelling operating license, etc. (control). Such an approach has been effective (i.e. high levels of stakeholder compliance) in developed markets due to social norms, greater environmental awareness among consumers, high institutional capacity for enforcement and monitoring, etc. Also, in the presence of a pre-legislative e-waste processing network, the

implementation model was designed to accommodate and strengthen the existing network. For example, e-waste processing network had evolved in Switzerland much before its Government enacted take-back legislation (Khetriwal et al., 2009). The network consisted of a monopolistic collective system initiated by few major electronics manufacturers. The implementation model for proposed take-back legislation was designed to accommodate and strengthen the existing processing network. *Developed markets being first movers to enact product take-back legislations, their models have been used as templates by emerging markets like India and China*. But, this approach is less likely to be effective in emerging markets due to unique challenges in operationalizing product take-back legislation (Akenji et al., 2011). The unique challenges in emerging markets are summarized below:

(1) Difficulties in identifying manufacturers for mandating the responsibility due to the presence of non-branded products assembled in small repair shops, and large presence of smuggled & counterfeit products (Kojima et al., 2009).
(2) Significant presence of Informal Processors which consists of groups of workers who engage in rudimentary operations (with low set-up and operating costs) in the collection and disposal of e-waste for their livelihood, with negative consequences to health and environment (vis-a-vis the Government authorized processors with better technology). Consumers prefer to sell e-waste to Informal Processors, as they pay a higher amount than the Government authorized processors. *Existing implementation models of product take-back legislation in emerging markets have ignored these Informal Processors*. The implementation model mandates them to register with the Government and become a formal processor.
(3) Poor compliance by stakeholders due to lack of environmental awareness, incentives, social norms, institutional capacity for enforcement and monitoring (Kojima et al., 2009; Akenji et al., 2011). For example, India enacted product take-back legislation for lead-acid batteries in 2001 based on command-and-control approach. Even a decade after the implementation, negative externalities persist due to processing in the informal economy, poor compliance by stakeholders, small assemblers producing and selling non-branded batteries (Occupational Knowledge International, 2010; Handique, 2010a; Handique, 2010b; Rao, 2011).

These unique challenges, in emerging markets, exist not only for e-waste processing or e-waste product take-back legislation. Rather, such challenges exist for any economic activity in

emerging markets. This due to unique business history of emerging markets that are characterized by long periods of colonization, extensive Government intervention in business, institutional inefficiencies, persistent presence of informal economy, etc. (Austin et al., 2017).

2.3 Research gap

Implementation models of product take-back legislation in emerging markets, need to be designed by incorporating these unique operational issues. However, OM scholars have typically focused on developed market contexts. The unique operational issues in emerging markets are not incorporated in the existing theorization on e-waste product take-back legislation in OM literature. To develop generalizable theories on e-waste product take-back legislation, more understanding is needed about markets (countries) other than the developed ones. Hence, there is a need for studying emerging market contexts. OM scholars have recognized that country specific constraints moderates the expected impact of product take-back legislation and more empirical research is needed to extend the existing body of knowledge (Atasu & Wassenhove, 2012). They have said:

> "It is also clear that a one-size-fits-all best case solution would not apply in different parts of the world and to different business environments. In other words, a successful policy model and implementation in one country may not necessarily work in another; not only because welfare perspectives may differ but also because operational constraints vary significantly between countries."

A focused study of one emerging market to understand and resolve the unique challenges would generate insights that are relevant across other emerging markets. For example, insights obtained by studying operational issues in India could be of relevance to emerging markets with comparable market depth and similar standards of waste disposal i.e. such emerging markets can use the template of India (rather than using the template of developed markets) and modify them to develop implementation models that suit their context. In this dissertation, we focus on India to understand and resolve some of the unique issues. Our focus on India, to improve theorization in the broad area of sustainable operations, is also consistent with the calls made by OM scholars to study emerging markets (Lee & Tang, 2017). This research gap is illustrated in Figure 4.

Figure 4: Research gap in e-waste product take-back legislation

Developed Markets	Atasu & Wassenhove (2012) Plambeck and Wang (2009) Toyasaki et al. (2010) Atasu et al. (2013) Gui et al. (2013), Alev et al. (2015)	Besiou et al. (2012)
Emerging Markets	X	Bhaskar & Turaga (2017) Mahajan & Vakharia (2016) ***Research Gap explored in this quadrant***
	- Small presence of informal economy - High stakeholder compliance	- Large presence of informal economy - Low stakeholder compliance

In addressing in research gap, we join the conversation of scholars who are studying this topic using an operations or management perspective. *This research gap was strengthened during the pilot field study conducted during April-May 2011, with a few stakeholders*[10]. At this time period, draft document of e-waste product take-back legislation had already been prepared (this was prepared by MoEF in 2010). This legislation was called E-waste Management & Handling Rules (EMHR). MoEF formally enacted this legislation in May 2011 (during this pilot study) which was due to be effective from May 2012. During this pilot study, we interacted with 9 stakeholders in the e-waste processing industry to understand their perspectives. Profile of these stakeholders are as follows:

- ✓ 2 Formal Processors (one of them was the first Formal Processor in India)
- ✓ 1 informal-turned-formal processor
- ✓ Representatives from 2 NGOs that worked on e-waste awareness and collection
- ✓ Senior Officer of a Governmental organization that enforces and monitors environmental legislations
- ✓ A policy expert who was involved in preparing the draft document of EMHR
- ✓ An entrepreneur who was preparing to enter this industry, by setting up a firm for manufacturing machinery to process e-waste

This was coupled with unobtrusive visits to consumer electronics retail stores in Bangalore to dispose e-waste and interact with store managers. This pilot study revealed that the topic of

[10] This pilot study was done during the 1st year summer break of doctoral programme. Details of this pilot study can be made available, upon request.

operationalizing Product Take-Back Legislation for E-waste was of central concern in India. Discussions during this pilot study were centered on how best to operationalize this take-back legislation, how to make stakeholders comply with the take-back legislation, and how to incorporate the informal economy in take-back legislation. Interactions with these stakeholders also revealed interesting/unique events happening *out there* in this phenomenon, which was less discussed in academic literature. For example, we came to know about Informal Processors becoming Formal Processors (in Bangalore), possibilities of big Formal Processors selling e-waste to Informal Processors, and an insufficient understanding of end-to-end reverse supply chain. Discussions with these stakeholders revealed that if Informal Processors were incentivized to become part of the formal economy, the hardest part of e-waste problem would be resolved. This would also enable stakeholders to comply with EMHR. Besiou et al. (2012), by studying the Informal Processors in Greece, had argued that designing an e-waste take-back legislation by incorporating Informal Processors into the formal economy is superior with respect to economic, environmental, and social dimensions. They also called for research to develop incentive schemes to encourage Informal Processors become part of the formal economy. Given the large presence of informal economy in India, it was relevant to ask this question: *How to incentivize informal e-waste processors to adopt safe, scientific methods and become part of the formal economy*?

The rationale for asking this question was also strengthened through conversation with the Proprietor of an informal-turned-formal firm (Alpha[11]) during the pilot study in 2011. Proprietor of Alpha, who had worked for a decade in the informal economy, was enthusiastic about his new firm. He placed hopes on the forthcoming EMHR, to scale-up his firm. Thus, we realized that if there are incentive schemes to encourage Informal Processors become formal, this could be a potential solution to the e-waste problem. This idea was also suggested by other stakeholders, during this pilot study.

However, to develop such incentive schemes, one needs to understand the following contextual phenomenon:

[11] Alpha is a disguised name of the informal-turned-formal firm. The proprietor of this firm was again interviewed during 2014-2016, during the full-fledged field study.

(Q.1) *Formalization of Informal Processors*: How did some of the Informal Processors become formal (i.e. Government authorized)? What was their formalization process? What operational challenges did they face while transitioning from informal to formal?
(Q.2) *Structure of Reverse Supply Chain*: What are the sequence of processes involved in transforming e-waste into revenue generating recyclables? Who are the stakeholders involved in this transformation process and how do they transact?

We provide the definitions of Informal and Formal Processors, once again, to bring clarity. E-waste processors in the informal economy (Informal Processors) are not authorized or recognized by the Government and do not pay taxes. Such firms are engaged in unscientific processing and disposal (with low set-up and operating costs) of e-waste, with negative consequences to public health and environment. E-waste processors in the formal economy (Formal Processors) are authorized and recognized by the Government and pay taxes. Such firms are engaged in scientific processing and disposal (better technology with higher costs) of e-waste, without harming public health and environment.

Informal Economy means economic activities undertaken by unregistered firms (i.e. not legally recognized by the Government) and unregistered economic activities undertaken by registered firms (Neuwirth, 2011; Webb et al., 2009). Firms engaged in such activities, do not pay taxes and cannot be monitored by the Government for compliance (smuggling, environmental protection, etc.). Such firms exist in various industries like auto component manufacturing, street-side flea business, recycling, healthcare services, etc. (Neuwirth, 2011; Webb et al., 2009). Economic activities in the informal economy contribute to 17% of GDP in developed markets and 40% of GDP in emerging markets (Schneider, 2002). As per recent estimates, informal economy contributes to 32% of the world GDP (Medina & Schneider, 2018). In India, informal economy contributes to 45% of Net Domestic Product, excluding non-agricultural activities (Vaidyanathan, 2014). The 68th round of NSSO survey (conducted in 2012) report that informal economy contributes to 70% of employment in the non-agricultural sector. In the Indian context, informal economy measurement also includes activities by proprietorship/partnership firms (i.e. these firms are not separate legal entities independent of their owners). In the e-waste processing industry, informal economy contributes to processing 95% of e-waste (Assocham Report, 2016). Sadly, ‘employees’ in this informal economy includes 5 lakh children in the age group of 10-14 (Assocham Report, 2016).

Literature on formalization of informal e-waste processors: There is little academic literature to answer the research questions. Theorization on firms operating in the informal economy and their formalization process is scant in management literature (Godfrey, 2011; Bruton et al., 2012; McGahan, 2012). For example, the 2012 Academy of Management Conference held at Boston had the theme *The Informal Economy*. This was a call to management scholars to study and theorize on firms in the informal economy. Understanding formalization of informal e-waste processors, responds to recent calls by management scholars to study firms in the informal economy. For example, Bruton et al. (2012) posed the following questions for management scholars:

> "In terms of operations management, many informal firms skirt labor or pollution or other operations-related regulations. As such, are these choices accompanied by other operational adaptations so the firms can avoid monitoring/enforcement? From an organizational development/change perspective, what are the motivations that cause a firm to transition from informal to formal? Do such motivations change the informal firm in ways other than simply registering with the government?"

Though scholars in economics & public policy disciplines have studied firms in the informal economy, they focus on different set of questions. This stream studies big-picture questions using theoretical (i.e. stylized economic modelling) and empirical (large-sample econometric modeling) approaches. Key questions studied are as follows (Marjit & Kar, 2011): What is the impact of deregulatory policies on the welfare of informal workers? What are the implications of open and liberal economic environment for informal unskilled manufacturing & agricultural sector? How wages in the informal sector respond to unemployment in the formal sector (of individual industries)? How do changes in exogenous policies (like free trade agreements, etc.) in the formal sector affect wages and employment conditions in the informal sector? This stream of literature also argues that informal economy is not a transitory phenomenon and policies need to be designed to provide social security net and protect the informal labor that is often over-exploited. Kundu & Sharma (2001) discuss macro-issues like impact of global conditions on wages, productivity, informal-formal linkages, etc. and micro-issues like case studies of formalization. For example, formalization of head-load workers in Kerala, formalization of informal workers in different industries (like restaurants, street food, etc.) through formation of co-operatives are discussed. However, this stream of literature does not study the e-waste processing industry. The existing formalization cases discussed in other

industries (in the forward supply chains) are not at an operational-level and the focus is towards social welfare aspects. Hence, this body of knowledge, though useful, is not directly applicable to study our question.

Webb et al. (2009) classified informal economy activities along 4 dimensions: legality, legitimacy (i.e. social norms/acceptability), final products (ends), and production process (means). Their classification is reproduced in the following figure.

Figure 5: Classification of Informal Economy

<table>
<tr><td colspan="3"></td><td colspan="3">Ends</td></tr>
<tr><td colspan="3"></td><td>Legal</td><td>Illegal</td><td>Illegal</td></tr>
<tr><td colspan="3"></td><td>Legitimate</td><td>Legitimate</td><td>Illegitimate</td></tr>
<tr><td rowspan="3">Means</td><td>Legal</td><td>Legitimate</td><td>Formal economy</td><td>A</td><td rowspan="2"></td></tr>
<tr><td>Illegal</td><td>Legitimate</td><td>B</td><td>C</td></tr>
<tr><td>Illegal</td><td>Illegitimate</td><td colspan="3"></td></tr>
</table>

Informal economy in e-waste processing, broadly falls under blocks A, B, and C.

Block C: A neighborhood scrap dealer burns wires (means) to extract copper, and sells the copper to another scrap dealer (ends).

Block B: A neighborhood scrap dealer burns wires (means) to extract copper, and sells the copper to a large registered cable manufacturing firm (ends).

Block A: A registered (formal) e-waste recycler extracts copper from wires using safe process, and sells the copper to a scrap dealer (ends).

In the dark grey patch, ‘means’ and ‘ends’ are illegal and illegitimate. Some examples are drug cartels, bank robberies, terrorist groups, etc. The broader society do not confer legitimacy to such activities.

Literature on e-waste reverse supply chain: To the best of our knowledge, there is no published academic literature that describes the structure of e-waste Reverse Supply Chain in India. E-waste is transformed into revenue generating recyclables through a sequence of processes/activities starting from disposal by consumers, to e-waste processing by Processors (informal or formal), and finally reaching other markets. In OM literature, this network of processes/activities starting from disposal by consumers is defined as Reverse Supply Chain (RSC) (Guide & Wassenhove, 2002). The traditional forward supply chain is concerned about

delivering products or services to consumers. The forward supply chain is defined as a network of various stages including suppliers, manufacturers, distributors, retailers, and consumers through which products, information, and money are transformed to deliver products or services to consumers (Chopra & Meindl, 2004). In a similar vein, the RSC for e-waste is also a transformation process consisting of a network of various stages including consumers, retailers, scrap traders, manufacturers, formal processors, informal processors, and scrap metal smelters through which e-waste, information, and money flow. A detailed understanding of this RSC is important to propose appropriate incentive schemes for formalization. Mapping of an end-to-end supply chain (e-waste RSC, in this case) using systematic field research is rare in OM literature (Seuring, 2008). Our focus here, is to develop an industry-level, end-to-end understanding of the e-waste RSC. To this end, our unit of analysis is not at firm-level, rather it is at an industry-level (Joglekar et al., 2016). Prior literature appears in the environmental economics discipline that adopts a micro-level view of few select stakeholders in the lead-acid battery RSC (Gupt, 2015; Chakrabarti & Mitra, 2005). There exists scarce academic literature that describes the e-waste RSC from an industry-level perspective.

Thus, lack of ready-made answers/understanding in the academic literature and practice, necessitates the study of Q.1 and Q.2. For example, a prevailing consensus among practitioners (revealed through the pilot study) is formalization would help the informal processors to scale their business, thus improving profits and minimizing the negative environmental impact. This prevailing consensus is not supported by field evidence. Similarly, there is lack of a rigorous industry-level understanding of the e-waste RSC. Thus, nature of these questions are exploratory/descriptive[12] due to the nascent state of knowledge in this stream of research.

In this chapter, we have reviewed relevant literature on the topic of e-waste product take-back legislation. The dissertation is positioned within the broad research stream of Sustainable OM (shown in Figure 3). Research gap is identified within the sub-stream of e-waste product take-back legislation leading to development of the research questions (shown in Figure 4). This research gap is strengthened based on the pilot field study, and research questions are developed. In the next chapter, we discuss the conceptual framework and methodology to investigate answers to these questions.

[12] Words "exploratory", "descriptive" are used synonymously in this dissertation. The key idea is as follows: exploring the boundaries of phenomena and describing them in detail.

Chapter 3A: Methodology & Conceptual Framework

In this chapter, we discuss appropriate methodology, develop conceptual framework and propositions to answer the research questions. This development of conceptual framework is preceded by a discussion on the philosophical underpinnings of this research study.

3A.1 Appropriate methodology & philosophical underpinnings

Given the nature of research questions (descriptive/exploratory), and the nascent state of knowledge (prior literature) available to answer these questions, qualitative exploratory case study research is appropriate (Sekaran & Bougie, 2009; Zikmund, 1997; Edmondson & McManus, 2007). There is little knowledge (based on literature review) regarding concepts that explain formalization of informal e-waste processors and the structure of e-waste RSC. Edmondson & McManus (2007) characterizes theorization of such phenomenon (with little knowledge), to be at a nascent stage. In such a situation, an appropriate methodological choice is to conjecture about some potential concepts based on logic & related literature, conduct qualitative case study (i.e. field research) to revise and refine these conjectures, and develop grounded understanding of what concepts operate in the phenomenon. This is known as *exploratory qualitative case study research methodology* (Yin, 2009). Such qualitative case studies are not new to OM discipline. Senior OM scholars have pointed out that classic theories/conceptual frameworks in OM have come from qualitative case studies (Singhal & Singhal, 2012). For example, OM concepts like Product-Process Matrix, Focused Factory, DNA of Toyota Production System, Eight Dimensions of Quality, Modular Production, Customer contact model of Services, etc. were developed from qualitative case studies (Singhal & Singhal, 2012).

If a researcher were to *hit the field* and explore *what is going on*, there is one aspect that needs to be specified in-advance. What the researcher expects to observe while conducting field study, is dependent on *how* she observes the phenomenon and *what* she thinks to be valid knowledge[13]. Based on the philosophical orientation, the researcher observes only certain aspects of the phenomenon and believes certain forms of knowledge acquisition as valid.

[13] In philosophy of science, this is called as ontology (what reality/aspects of the phenomenon does she observe) and epistemology (what evidence from the phenomenon is believed to be valid knowledge).

Scholars in International Business (IB) and Information Systems (IS) have explicitly differentiated between various philosophical orientations (or underpinnings) to qualitative case study research i.e. based on the researcher's philosophical orientation, the approach she takes would be different (Welch et al, 2011; Myers & Avison, 2002). A researcher with philosophical orientation in positivism would assume that there is objective reality *out there* and she would want to *dig out that reality*[14]. This researcher believes in the natural science model of doing social science research. A researcher with philosophical orientation in interpretivism would assume that there is *no objective reality out there*. Rather, the reality is socially constructed by people. In this case, the researcher assumes that all knowledge is subjective and she would want to understand the phenomenon through the subjective experience of people. A researcher with philosophical orientation in critical theory (origins in Marxism) would assume that reality is historically constituted and she would want to understand the phenomenon by exposing deep-seated, structural contradictions within society. She would believe that though people can change their social circumstances, the capacity to make such a change is constrained by prevailing economic, political systems, and authority. A researcher with philosophical orientation in critical realism would want to explicitly describe causality by identifying the generative mechanisms (e.g., according to this orientation, it is also possible that an actual causality which exists, cannot be perceived by the researcher). These philosophical orientations are not exhaustive nor discreet. Rather, they are fluid and should be seen as a continuum. Interested readers may refer to Welch et al. (2011) and Myers & Avison (2002) for a detailed explanation of these philosophical orientations and their approaches.

In this study, we use the philosophical orientation of positivism[15]. Our objective is to *dig out the reality* i.e. to dig out the structure of reverse supply chain, formalization process. Our objective is not to study the subjective experience and meaning of informality as construed by the Informal Processors (interpretivism) or to expose deep-seated structural imbalances in society that has led to the divide between formal and informal (critical theory), etc. Rather, the objective of this study is to understand some concepts/characteristics that are commonly related to the phenomenon of formalization and RSC. This understanding would help in designing policies that can be applied across different organizations in the e-waste processing industry.

[14] This metaphor of digging out the reality is from Mason, J. (2002). *Qualitative Researching*. Sage Publications.
[15] Nature of research questions asked by a researcher could also be based on her inherent philosophical orientations, unknown to her. So, a researcher would not be able to *choose* a particular philosophical orientation. But, discussion of such deep philosophy, though useful, are outside the scope of this dissertation.

This approach of using the philosophical orientation of positivism to understand general concepts/characteristics of a phenomenon relevant to public policy, is consistent with the suggestions provided by scholars in industry studies and public policy literature (Joglekar et al., 2016; Lin, 1998; Sako, 2008). For example, Sako (2008) called for a methodology to observe and understand a phenomenon in all its complexity i.e. firms, employees, markets, and Government that designs policies targeting the industry, and then build general theories to explain what one observed. This includes listening to multiple stakeholders' perspectives and using multiple sources of evidence for triangulation. The philosophical orientation of such a methodology is positivism (Lin, 1998).

3A.2 Positivist qualitative case study research

Two seminal works in management scholarship for doing case study research are Eisenhardt (1989) and Yin (2009). Both these approaches are based on the philosophical orientation of positivism (Welch et al., 2011). Eisenhardt (1989) advocates an inductive approach and focus on theory building case research when little is known about the phenomenon i.e. in the exploratory phase. But, Yin (2009) advocates a deductive approach and a more holistic use of case study research for exploratory, explanatory, and descriptive purposes i.e. not only to build theory, but also to refine, verify, test, and challenge existing theory (Welch et al., 2011). From the point of view of philosophy of science, Welch et al. (2011) said that Eisenhardt's inductive approach is based on logical positivism (i.e. principle of verification) and Yin's deductive approach is based on post-positivism (i.e. principle of falsification advocated by Popper (1959)).

In this study, we choose Yin's approach for case study research and use his vocabulary throughout. The rationale for choosing this approach is described in the forthcoming section 3A.3. Yin (2009) defines the scope of case study as follows: "an empirical inquiry about a contemporary phenomenon in depth and within its reafl-life context, especially when the boundaries between phenomenon and context are not clearly evident". This scope is appropriate for our study which is phenomenon-driven (e-waste RSC, formalization) and context sensitive (Indian context). Yin (2009) defines research design to be a logical plan to derive some set of conclusions from the initial research questions. The five important components of case study research design are as follows: "a study's questions; its propositions,

if any; its unit(s) of analysis; the logic linking the data to the propositions; and the criteria for interpreting the findings" (Yin, 2009). The study's questions are the initial research questions. Specifying the form and substance of questions is important. The form (i.e. what, why, how) of the questions helps to choose an appropriate research methodology. The substance (i.e. formalization, structure of RSC) of questions helps to establish the significance that contributes to extending knowledge. While the study's questions focus on what questions are worth answering, the study's theoretical propositions provide focus on what should be studied within the scope of the questions posed. *Yin advocates developing specific propositions before beginning the exploratory case study*. These propositions need to be developed from academic literature that is related to the phenomenon i.e. the researcher should read a range of existing theories, understand them, and decide whether & how to use them as propositions for the case study. In the absence of related academic literature, non-academic literature needs to be referred. If there is no rich literature, the propositions can even be a hypothetical story of why certain acts, events occur that explain the phenomenon. The idea behind developing propositions, before fieldwork, is to have an understanding of what is being studied. The meaning and purpose of propositions in case study research can be better understood by using Karl Weick's *metaphor of a postcard and art museum*[16]. Weick (2007) said why a postcard reproduction of art needs to be seen, before seeing the actual art at the museum:

> "The next time you visit an art museum, before you actually view the exhibit itself, go to the gift shop. Purchase postcard reproductions of several items that are hung in the gallery. When you get to the original work of art, hold the postcard reproduction alongside the original. What you will discover is that portions of the painting are not well reproduced on the postcard (e.g., the background isn't that color, the sparkle in the original is missing from the reproduction, changes in perspective are more dramatic, etc.). The postcard essentially alerts you to features of the painting you might otherwise have overlooked. The imperfect reproduction serves as a clue to sites where the artist's genius is more evident. In similar fashion, what any event means, what is significant in its unfolding, may become clearer when it is compared with another event, and the observer looks for similarities and differences. […] Go into inquiry clear about what you expect, what you believe. That is your postcard."

[16] This metaphor used by Weick (2007) is from the following book: Parmenter, R. (1968). *The Awakened Eye*. Middletown, CT: Wesleyan University Press.

Linking this metaphor with our study, *postcard reproduction of art* is the set of propositions developed prior to fieldwork and *actual art displayed in the museum* is the real-life phenomenon which one observes during fieldwork.

According to Yin, even for an exploratory case study where there is no rich literature, a hypothetical story needs to be developed i.e. idealized scenarios (hypothetical description) of what can be expected in the field. These idealized scenarios are not like the traditional propositions. Rather, they are more like statements. To distinguish between propositions and statements, we describe ideas from Bacharach (1989) that compares and contrasts propositions and hypotheses. Constructs (or concepts) are broad mental configurations of a given phenomenon and proposition is relationship between constructs (Bacharach, 1989). Variables are operational configurations derived from constructs and hypothesis is relationship between variables (Bacharach, 1989). Within the context of organizational studies, Bacharach (1989) provided an example to distinguish between proposition and hypothesis. If one were to study the relationship between size of an organization and its horizontal differentiation, following would be the proposition, hypothesis, and statement:

Proposition (relationship between mental constructs):

> "Greater the organizational size, greater the horizontal differentiation."

Hypothesis (relationship between variables):

> "Greater the number of employees, greater the number of departments."

Statement (description of the constructs)[17]:

> "Organizational size & horizontal differentiation can be low, medium, or high."

For an exploratory case study that explores or describes a phenomenon, one needs to develop statements (Yin, 2009). This provides the focus (breadth and depth) for doing case study. If such statements are not articulated before beginning the case study, one would look for all kinds of evidence and there is a high chance that one may collect evidence aimlessly. Depending on the phenomenon being researched, there would be some expected patterns while describing it. These expected patterns are articulated as propositions. These expected patterns

[17] Bacharach (1989) only distinguished between proposition and hypothesis. We have included *statement* in his example to illuminate our point of view.

will not be similar to statements. *Articulating these propositions and statements beforehand, helps to collect relevant evidence and choose appropriate data analysis technique*. For an exploratory case study, the proportion of statements will be higher than propositions because the objective is description. Though we have distinguished between statements (idealized scenarios) and propositions, the hypothetical scenario in-itself is a kind of proposition i.e. these scenarios are proposed by the researcher before beginning the field work. Thus, for the purpose of doing this study, such idealized scenarios are also called as propositions for which the researcher needs to find evidence from the field.

We would like to make a distinction between deductive method (advocated by Yin's approach to qualitative research) and pure deductive method. In the pure deductive method, some *grand theory* (available in social science/management literature) is proposed and tested against the empirical evidence. This is commonly done in theory-driven research. But, in Yin's deductive method, the researcher formulates/develops some *working propositions*, tests them against empirical evidence, and refines these working propositions. This is suited for phenomenon-driven research where the goal is to explore/describe a phenomenon in its totality. However, deductive method advocated by Yin, is not averse to providing flexibility in the research design or noticing emergent patterns that were not hypothesized as propositions.

3A.3 Rationale for choosing Yin's approach

For a serious qualitative methodology scholar, Yin's approach would *seem to be* merely theory testing which is not the way qualitative research is traditionally done. Traditionally, qualitative research is assumed to be *inductive*, *grounded*, *bottom-up*, etc. which leads to theory building. Let us re-emphasize the rationale for using Yin's approach that is deductive/propositions-driven. There are few points we wish to invoke from methodology literature, before justifying the propositions-driven approach to qualitative case research. Methodologists have arrived at the consensus that qualitative case research, using small number of cases (or samples), is useful not only for building theory, but also for theory testing and theory elaboration (Flyvbjerg, 2006; Denzin & Lincoln, 2011). Scholars from other management disciplines like IS have arrived at this consensus long time ago (for example, see Lee (1989)). Recently, OM scholars have also begun to discuss the usefulness of case research methodology in theory testing and theory elaboration (Barratt et al., 2011; Ketokivi & Choi, 2014). This means that qualitative research,

apart from exploring/describing phenomena, is also useful for building, testing, and elaborating/extending theory.

OM scholars have used propositions-driven approach to qualitative case study research. For example, Stuart et al. (2002) advocates developing propositions before entering the field. Specifically, they said:

> "Whether a case study is intended primarily to explore, to extend theory or to gain understanding, it requires an explicit, up-front statement of its intentions. [...] Focus and ultimate success is further enhanced if the study's basic questions are translated into propositions. For example, rather than leaving a study's focus as 'what are the most important considerations for production managers in making decisions about short-term scheduling?', a researcher may hypothesize that one or two specific considerations may be more important than others, or that the primary drivers differ with specific industry characteristics. [...] Having explicit propositions pushes the researcher to structure what results should be expected and what constitutes reasonable evidence for or against the proposition."

Done et al. (2011) studied factors that influence short-term and long-term operational improvement in Small and Medium Enterprises (SMEs) after a Best Practice Intervention (BPI). Using qualitative case study research, they studied eight SMEs in United Kingdom that implemented lean production practices. They developed 11 propositions from existing academic literature, before entering the field. Evidence collected from the eight SMEs were used to support and revise (i.e. if refuted, revise the proposition) these 11 propositions. Evidence collected from the field were also used to develop new propositions. Mollenkopf et al. (2011) used propositions-driven qualitative case study research to study inter-functional interaction (specifically interaction between marketing and operations) during product returns management process at a global appliance manufacturer. They developed four propositions from existing academic literature, before entering the field. Evidence collected from the appliance manufacturer was used to support and revise these four propositions. While doing this, they also listed the emergent themes which emerged from field evidence i.e. what other factors (not hypothesized) influenced the inter-functional interaction. Ellram et al. (2008) had also used a similar approach to study how firms manage the costs and risks of outsourcing professional services offshore. Theoretical lens of transaction cost economics was used to

develop propositions before entering the field. These propositions were revised based on field evidence. They were also open to emerging or new factors that may influence costs and risks of offshore outsourcing. *Thus, propositions-driven qualitative case research has been used by OM scholars and these studies have been published in the leading journal in OM that publishes empirical research (Journal of Operations Management).*

Barratt et al. (2011) discussed state-of-the-art of qualitative case research in OM. They reviewed qualitative case studies published between 1992 and 2007 in five OM journals (Decision Sciences Journal, International Journal of Operations and Production Management, Journal of Operations Management, Management Science, and Production & Operations Management). They distinguished between inductive and deductive approaches used by OM scholars for doing qualitative case research. Out of the 204 qualitative papers published between 1992 and 2007, 169 had used inductive (Eisehardt) approach and 35 had used deductive (Yin) approach. Barratt et al. (2011) reported the following problems in published papers that used deductive aprooach (i.e. Yin's approach that is propositions-driven):

- Research protocols for deductive approach are not well-developed when compared to inductive approach.
- Majority of the papers that used deductive approach did not justify their rationale (i.e. why deductive and not inductive).
- Papers that used deductive approach adopted an inductive logic (using within-case analysis, cross-case analysis rather than pattern matching technique) for presenting data analysis.

It is relevant for our discussion to quote the following from Barratt et al. (2011):

> "The typical deductive paper is focused on revising existing frameworks/hypotheses or describing a phenomenon, using a single case with within-case analysis. However, it does not clearly articulate research questions and its unit of analysis. In the absence of clear research protocols, it adopts inductive logic for deductive purposes. For instance, the qualitative data that support hypotheses are compiled inductively and then are used for deductive means to claim support. It imparts a strong impression that the authors selectively chose evidence to justify confirmation of their hypotheses."

Barratt et al. (2011) also suggested a protocol for deductive approach to qualitative case research. But, their suggestion can be used only for theory-driven research (Our research is not theory-driven. We will discuss this in detail, later). However, their suggestion to use pattern

matching technique (also suggested by Yin) during the data analysis phase is valid and followed in this study. We have certain observations on the state-of-the-art of qualitative research in OM. Firstly, *OM scholars do not explicitly discuss the philosophical orientations/underpinnings of their qualitative research methodology unlike their counterparts in disciplines like IS*. This could be because qualitative research methodology is still emerging in OM (OM discipline is dominantly oriented towards to stylized analytical modeling, econometric modeling), while it has reached a mature status in other disciplines like IS. Scholars in IS, discuss explicitly various philosophies like positivism, interpretivism, critical theory, and critical realism while designing and conducting qualitative research (Myers & Avison, 2002). Recently, scholars in IB have also started discussing the same. As explained before, Welch et al. (2011) distinguished between Eisenhardt's approach and Yin's approach to positivist case research. Eisenhardt's approach is based on the philosophy of logical positivism (inductive/no propositions before entering the field), while Yin's approach is based on the philosophy of post-positivism (falsificationism/deductive/propositions-driven).

Eisenhardt (1989) clearly articulated her philosophy in her seminal paper, as follows:

> "…theory-building research is begun as close as possible to the ideal of no theory under consideration and no hypotheses to test. Admittedly, it is impossible to achieve this ideal of a clean theoretical slate. Nonetheless, attempting to approach this ideal is important because preordained theoretical perspectives or propositions may bias and limit the findings. Thus, investigators should formulate a research problem and possibly specify some potentially important variables, with some reference to extant literature. However, they should <u>avoid thinking about specific relationships between variables</u> and theories as much as possible, especially at the outset of the process."

Yin clearly articulated his philosophy in his seminal books on case study research, as follows:

> "Our approach has been to place case study research within the framework of the scientific method - to develop hypotheses, collect empirical data, and develop conclusions based on such data. The result is not claimed to be science but the emulation of the scientific method." – (Yin, 2003)

> “When Christopher Columbus went to Queen Isabella to ask for support for his ‘exploration’ of the New World, he had to have some reasons for asking for three ships (Why not one? Why not five?), and he had some rationale forgoing westward (Why not south? Why not south and then east?). He also had some (mistaken) criteria of recognizing the Indies when he actually encountered it. In short, his exploration began with some rationale and direction, even if his initial assumptions might later have been proved wrong. This same degree of rationale and direction should underlie even an exploratory case study.” – (Yin, 2009)

It is evident from Barratt et al.’s (2011) review that qualitative case study researchers in OM have used a combination of Eisenhardt and Yin and have not distinguished between the two. *It has become customary in OM community to cite Eisenhardt and Yin, whenever one does qualitative case study research, whether inductive or deductive.*

As said before, though Barratt et al. (2011) have suggested a protocol (that compares complementing, competing theories that explain a phenomenon) for deductive approach, their suggestion can be used only for theory-driven research. *This research study is not theory-driven*. Suppose, we were trying to understand how manufactures/stakeholders respond to product take-back legislation in Indian context, using the lens of contingency theory. This would be a theory-driven research. For example, Bhakoo & Choi (2013) studied how organizations in different tiers of the health care supply chain respond to institutional pressures, using the lens of institutional theory. They used an inductive approach (i.e. Eisenhardt’s approach and not Yin’s approach) and developed six propositions based on field evidence. In another context, Tripathy & Eppinger (2011) studied how organizations manage their global product development activities for complex products, using the lens of product design and development theory (ex: design structure matrices). They used an inductive approach (i.e. Eisenhardt’s approach and not Yin’s approach) and developed propositions-based framework from field evidence. *Eisenhardt’s approach is suitable for such theory-driven research questions where theorization on a particular pocket of the phenomenon is at a nascent stage*. But, our research study is not of this kind. Rather, our research is *phenomenon-driven* and not theory-driven. Phenomenon-driven research is different from theory-driven research (von Krogh et al., 2012; Schwarz & Stensaker, 2014; Van de Ven et al., 2015). In phenomenon-driven research, the objective is to carefully describe and understand the phenomenon in all its complexity and position the findings with an appropriate theory or stream of literature. The

recently released journal, Academy of Management Discoveries, focusses exclusively on phenomenon-driven research (Van de Ven et al., 2015). This substantiates the importance of phenomenon-driven research in management. von Krogh et al. (2012) said the following about phenomenon-driven research:

> "With its emphasis on identifying, capturing, documenting, and conceptualizing a phenomenon of interest in order to facilitate knowledge creation and advancement, this approach focuses on contributing to knowledge within a field rather than to specific theory."

Such an approach to deeply understand a less-studied phenomenon is also espoused by OM scholars (Schmenner et al., 2009). Our research objective is to contribute to the conversation surrounding OM perspective on e-waste product-take legislation[18]. Extant literature has studied how product take-back legislations are implemented in various countries, modelled trade-offs faced by various stakeholders affected by this legislation, and suggested appropriate changes to improve such legislations. We have argued (section on literature review) that this literature is silent on the unique issues faced by emerging markets like India. Given that country contexts are important for the effectiveness of product take-back legislations, there is a need for understanding how e-waste is being managed in India. Naturally, being OM scholars, we held the process/supply chain lens to understand this. In this research, we need to understand what is the reverse supply chain of e-waste, how does it look like, what are its boundaries, etc. There are no such theories or frameworks, to the best of our knowledge, which are discussed in OM literature. For example, scholars have pointed out the lack of an overarching *theory of a supply chain* (Carter et al., 2015). Hence, we resort to understanding this phenomenon of e-waste reverse supply chains and formalization. Our fundamental objectives consists of the following:
(a) Describe reverse supply chain of e-waste within Indian context
(b) Describe formalization of informal processors within Indian context
(c) Develop understanding of the phenomena from this description
(d) Based on this understanding/formulation, suggest implications for public policy (i.e. incentives to encourage informal processors to become formal)

[18] The research objective is repeated in this section for improved clarity of discussion.

Parts (a) and (b) are where we have to *enter the field*. Now, the dilemma we had to face was whether to enter the field with propositions (Yin's approach) or without propositions (Eisenhardt's approach).

First option was to say: "We are going to use an inductive approach. We will enter the field without propositions. We have some idea of the e-waste reverse supply chain. There are *some* sources of e-waste, *some* people collect it, e-waste goes to informal processors and formal processors, they do *some* processing with e-waste, and they sell/give it (after processing) to somebody, etc. We will develop some interview questions like: What do you purchase? How do you purchase? What do you do with it? Where does it go? We can ask these basic 4 questions to each stakeholder in the reverse supply chain and based on her response, further questions can be asked. In this way, the interview is semi-structured i.e. we do have some basic questions which we will compulsorily ask, and along with that we will ask questions based on how the interview progresses. With this research design, we will describe the reverse supply chain and formalization i.e. parts (a) and (b)."

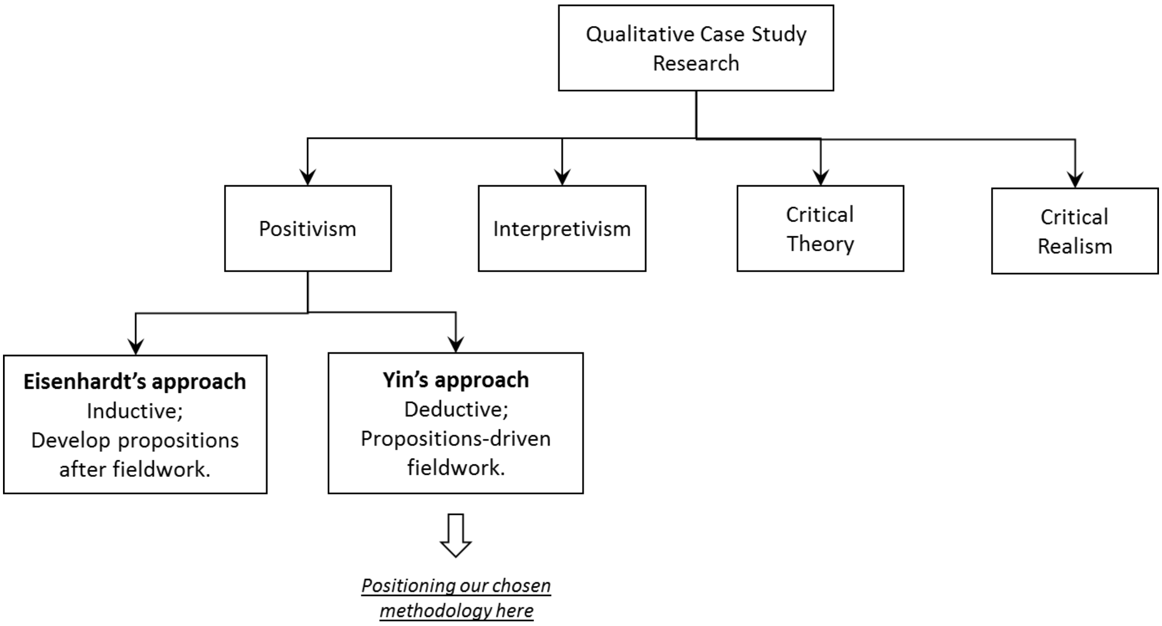
Second option was to say: "We are not going to use an inductive approach. We will enter the field with *some working propositions* that say something about the e-waste reverse supply chain and formalization. For example, rather than thinking (in our mind) that there are *some* sources of e-waste, we explicitly write it as a proposition: *There are three sources of e-waste: bulk consumers, retail consumers, and manufacturers*. What do we mean by bulk consumers, retail consumers, and manufacturers will be another proposition. Now, how did we arrive at this proposition? We had some prior knowledge which was obtained during the pilot field study, before framing this research question. We have certain expectations regarding how the e-waste reverse supply chain or formalization would look like. Based on this little prior knowledge, disciplined imagination, and some relevant literature we can develop propositions that describe the reverse supply chain and formalization. So, rather than thinking (in our mind) that some people collect e-waste and it goes to formal and informal, we develop specific propositions with an appropriate rationale. Based on these specific propositions (or working propositions), we can develop a list of questions to be asked to the respondents. In the process, we can also plan who the potential respondents would be. For example, by explicitly saying what the sources of e-waste are, we can plan to go to each of them and ask specific questions. Here too, the interview will be semi-structured. After developing these propositions and questionnaire, when we enter the field to collect evidence, we may find support for the propositions or we

may not find support or we may find partial support. If we do not find support or if we find partial support, this means we have obtained new evidence from the field which was not hypothesized a priori. Using this new evidence, we will revise the proposition. If we find new evidence that can enhance/refine a hypothesized proposition, we will revise the proposition. If we get evidence that confirms our propositions, this means that the proposition is not something that exists in our minds, it also exists in the field. The ultimate objective of these working propositions is to advance and direct our research i.e. help us to get what we want, from the field."

So far, we have explained the first option and second option. Now, the question is to decide which option to pursue for our research. We decided to choose the second option. There are two reasons for this decision. First reason is, having compared both the options for pursuing our research, second option is more water-tight when compared to the first option. *There is lower likelihood of not getting what we are looking for, if we choose the second option*. Second reason is, Yin's approach explicitly provides procedures/protocols to be followed for doing descriptive qualitative case research (phenomenon-driven). This is not the case with Eisenhardt's approach. For example, Pyecha (1988) had used propositions (based on hypothetical scenarios and available academic literature) for descriptive case study to document practices of a particular education system in schools. Pyecha's approach is illustrated by Yin (2003) as the best approach for a case study that explores and describes a phenomenon. We do not claim that one approach is superior to another (Eisenhardt versus Yin) or one form of reasoning is superior to another form of reasoning (inductive versus deductive). Philosophers of scientific reasoning have not yet reached a consensus on whether the actual nature of scientific reasoning is inductive or deductive (Mantere & Ketokivi, 2013; Okasha, 2002). But, they have reached a consensus that inductive and deductive forms of reasoning are needed for advancing research (Mantere & Ketokivi, 2013; Okasha, 2002). As researchers, the onus is on us to explain the rationale behind our approach (whichever approach or reasoning we choose). This helps to improve transparency in qualitative research methodology. *Given the objective of our research (to describe phenomenon), availability of a suitable protocol to conduct this research (Yin' case research approach), state of qualitative research in OM, and higher likelihood to get what we want from the field, we choose the second option*. We wish to re-emphasize that our working propositions are not akin to the conventional theory testing or hypothesis testing. Rather, these working propositions are intended to work like *nets to catch*

fish[19]. Size of mesh in the nets would determine what kind of fish can be caught. Our working propositions are equivalent to nets with meshes of a particular size to catch certain kinds of fish. Given the nature of exploratory research, this idea of working propositions is accepted in the scholarly community (Shields & Tajalli, 2006).The following figure illustrates our choice of methodology:

Figure 6: Positioning methodological choice



Because we develop propositions before entering the field, there is a possibility for *confirmation bias* in our methodology. The propositions should not be *thrust upon* the respondents. Confirmation bias means that we would be looking only for those evidence that supports our propositions and we would tend to avoid those evidence that does not support the propositions or that gives additional new information regarding the phenomenon (Nickerson, 1998). We address this potential problem using the following elements in our research design: (1) Consistent with the studies done by OM scholars (Done et al., 2011; Mollenkopf et al., 2011; Ellram et al., 2008; Stuart et al., 2002), we would be consciously open to new evidence from the field. Propositions would help us to look for some evidence *related* to that proposition. In the process, we would also be interested to observe what else is going on in the phenomenon that are not directly related to the propositions. We have also worded the questionnaire such

[19] This metaphor is based on Friedrich von Hardenberg's quote: "Hypotheses are nets: only he who casts will catch". This quote appeared in Popper (1959).

that the propositions are not thrust upon the respondents i.e. we have taken care to avoid asking leading, biased questions. Details regarding questionnaire preparation are discussed in the data collection section (Chapter 3B). (2) Our approach is not a conventional confirmatory hypothesis testing research. The propositions should be viewed as working hypotheses or *working propositions* which are amenable to revision based on what we find in the field. (3) Though we have been involved in the field for a long time (2 years), we have maintained *sufficient distance* from the respondents while analyzing the data. Data analysis was done in the confines of research cubicles at the institute (duration of data analysis was close to one year). Maintaining such a distance helps a qualitative researcher to warn herself against any kind of confirmation bias (if any) while analyzing the data. Such a rationale and approach has been emphasized in the classic qualitative methodology texts (Miles & Huberman, 1994).

3A.4 Conceptual framework to understand formalization

We reviewed academic literature to identify some concepts for formalization process or broadly related to formalization at an abstract level (like firm transformation, technology adoption). First, we discuss academic literature that is broadly related to formalization at an abstract level. Done et al. (2011) identified factors that influence short-term and long-term operational improvement in SMEs after a Best Practice Intervention (BPI). Using a case study research methodology they analyzed seven SMEs in United Kingdom that implemented lean production practices. They reviewed the literature on BPI to identify specific propositions. The BPI literature hinges on firms in the formal economy, whose operations management practices are well documented. These firms agreed to implement BPI due to the anticipated process improvements and consequently higher profits. At an abstract level, one may be tempted to use all the propositions used by Done et al. (2011) and test them in the context of formalization. This is because formalization could be considered as one kind of BPI, at an abstract level. But, our research context is different. The context we have, is that of a firm in the informal economy getting transformed to a firm in the formal economy by modifying or changing their e-waste processing operations. This transformation may not be intended to make profits because existing in the informal setup is always profitable. Rather, this transformation may be due to the realization that the current operational processes are harmful to health/environment, law of land not supporting informal processing, etc. Hence, we cannot use the specific propositions used by Done et al. (2011). What can be adopted from this paper are certain concepts like pre-intervention situation, objective of intervention, intervention process, and short-term and long-

term operational and financial outcomes. Bagri (2004) used a process model to understand the e-business adoption process in brick-and-mortar firms i.e. how e-business adoption process unfolds and its impact on the outcome of the adoption process. Process models “provide explanations in terms of the sequence of events leading to an outcome” (Langley, 1999). IT implementation literature was used to develop a theoretical framework for their study. Some concepts used in this framework like adoption motivation, adoption decision, and adoption implementation are adaptable to my research context. Yin (2003) reported a case study research that was done to understand how transformation occurred in fourteen manufacturing SMEs in USA. The case study team referred academic literature and consulted with experts to develop an initial theoretical framework “depicted as a logic model of sequential changes assumed to be causally related in a successful transformation process” (Yin, 2003). Logic model traces the chronological sequence of events where “events are staged in repeated cause-effect-cause-effect patterns” leading to the observed outcome (Yin, 2009). Each SME was a case (i.e. unit of analysis), logic models were developed for each case and matched with the hypothesized logic model, and cross-case synthesis done to derive insights. Yin (2009) also reported the use of logic models to understand how changes in a firm improved its manufacturing and business performance.

Next, we discuss academic literature on formalization of informal firms. Theorization on informal economy in management literature is scant (Godfrey, 2011). Perry et al. (2007) summarized, based on previous literature, two views of informality: exclusion and exit. The exclusion view says burdensome regulations to enter the formal sector prevent informal firms from being formal. The informal firms, who otherwise would have become formal, are *excluded* from the formal economy. The exit view says informal firms choose to remain informal because the costs of operating in the formal economy outweigh the benefits provided by formality. The informal firms *exit* or remain away from being formal due to the anticipated lower benefits (profits). de Mel et al. (2013) conducted a field experiment in Sri Lanka to empirically test exclusion/exit view of informality and benefits of formalization. The industry context was retail, manufacturing, and services. In the experiment, they gave two kinds of monetary incentives to informal firms to formalize: reimbursing direct costs of registering the firm and payment of two month’s profit. They found that firms choose to remain informal when the direct costs of registering are reimbursed. But, payment of two months’ profit induced half of the firms to become formal. Some firms, even after receiving more than two months’ profit, decided to remain informal due to land ownership issues. These firms operated on lands,

sometimes on government-owned lands, with informal agreements and were unable to provide the required proof of land ownership to the government authorities. The follow-up surveys of these firms done at 15, 22, and 31 months after formalization revealed that most firms make modest profits and do not gets the benefits of formalization like access to credit, obtaining government contracts, or participating in government programs. Thus, the findings from their study provide more support for exit view than exclusion view of informality (please refer de Mel et al. (2013) for details on the field experiment). Reddy (2013), using the philosophical orientation of critical theory, studied the biases and injustice involved in the formalization of two informal e-waste processors in Bangalore using evidence from primary and secondary sources. This is based on her fieldwork done in 2007-2008. Reddy's focus was to question the formalization phenomenon by probing the hidden agenda of capitalist firms in formal economy to *wipe out* the informal processing sector and to expose the inequalities (between formal and informal) in society.

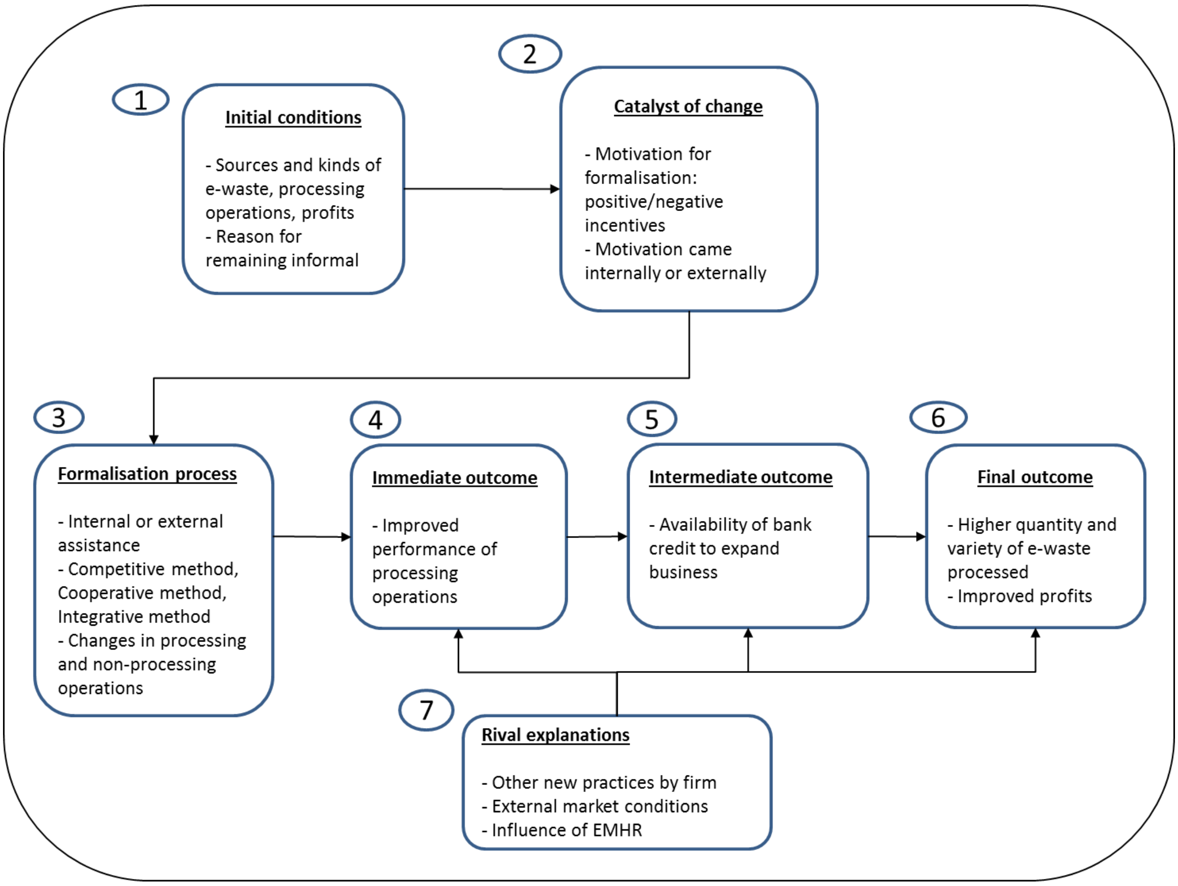
Using these two sets of academic literature and field knowledge (based on the pilot field study), we describe our understanding of formalization process. Based on this understanding, we develop specific propositions. Our understanding (hypothetical) of the formalization process, is as follows. An Informal Processor[20] processes e-waste using rudimentary operations and makes profit. The reason why this firm did not formalize and existed in the informal economy could be due to exclusion or exit view. This firm gets motivated to formalize due to positive or negative incentives. Two positive incentives are: anticipated higher profits as more e-waste can be obtained from new sources, operationally efficient e-waste processing; protect employees' health by modifying the processing operations. Negative incentive is the fear of harassment by law enforcement and monitoring agencies, because the informal operations are illegal. This firm is motivated to formalize, through positive/negative incentives, internally (i.e. individually) or through some external interventions (like NGOs). The firm decides to formalize and implements the formalization process. Formalization is done individually by the firm or external help is sought. Formalization process involves installing prescribed equipment for processing e-waste and obtaining registration from the respective State Pollution Control Boards (SPCBs). Formalization increases the cost of doing business when compared to the earlier situation where the firm was informal. This decreases the profits immediately after formalization. But, the performance of processing operations improve. In the intermediate

[20] The terms "Informal Processor" and "Informal Firm" are used synonymously in this dissertation.

stage after formalization, the firm procures e-waste from new sources. More variety and quantity of e-waste can be processed by the firm. This leads to improved profits to the firm in the later or final stage. The profits obtained in the final stage will be higher than what it could have earned being informal due to operationally efficient process and new sources of e-waste. This method of formalization necessitates competing with existing formal and informal-turned-formal processors. We call this method 'competitive'. There is also a second method to formalize. Rather than competing with existing Formal Processors and informal-turned-formal processors, the informal processor decides to cooperate with another Informal Processor and jointly become formal. We call this method 'cooperative'. The immediate, intermediate, and final outcomes are the same for both methods. But, the costs of formalization will be reduced and profits will be higher in the cooperative method when compared to the competitive method. There is a third method to formalize. In this method, the Informal Processor decides to cooperate with the Formal Processor. The Informal Processor does e-waste collection and simple (non-hazardous) processing operations for the Formal Processor. The processing operations, which are hazardous if the Informal Processor does it, are done by the Formal Processor. We call this method 'integrative'. Integrative method also requires the Informal Processor to install appropriate procedures to obtain government approval, but it costs less than the competitive and cooperative method. For the integrative method to work, the existing formal processor also has to take initiatives by offering appropriate contracts to the informal-turned-formal processor. The immediate, intermediate, and final outcomes are the same (at an abstract level) for all these three methods of formalization. But, the costs of formalization will be reduced and profits will be lower in the integrative method when compared to the competitive and cooperative methods. Lower profits are obtained because a large share (from the total profits) accrues to the formal processor. The final profits earned by the informal-turned-formal processor through any of the three methods (competitive, cooperative, integrative) will be higher than what it could have earned being informal. This theory/understanding of formalization is pictorially represented as a conceptual framework in Figure 7. This framework depicted as a logic model of sequential changes[21], is adapted from the firm transformation case studies reported by Yin (2003, 2009). This framework also includes the rival explanations that would influence the outcome of formalization. This is incorporated in the data collection protocol.

[21] We could have adopted process theory/model to understand the formalization process (Langley, 1999). We found process model akin to the logic model advocated by Yin (2009). Following Yin (2009) helps to be consistent with the vocabulary.

Figure 7: A conceptual framework of successful formalization of informal processors



Though we have described (hypothetically) a sequential model, we also recognize that actual process may not be strictly sequential and iterations between stages are possible (parallel stages are also possible). The data collection approach is designed to be sensitive to emerging field observations and this conceptual framework is amenable for modification. By successful formalization, we mean better operational and financial performance after formalization. This conceptual framework is operationalized into 12 propositions. These propositions are listed below:

Initial conditions before formalization

1) *Informal Processors process e-waste without any pollution abatement technology, protective equipment and make profits.*

This proposition says that informal processors does processing operations without installing any technology or equipment for protecting employees' health and environment. Informal processors are able to make profits by doing this.

2) *Informal Processors do not formalize because they perceive formalization to involve higher processing costs and consequently reduced profits.*

This is because formalization involves installing prescribed technology or equipment for safe processing. This increases their fixed costs and variable costs. Increasing costs reduces profits because revenue remains fixed. Thus, informal processors 'exit' from being formal due to anticipated lower profits.

Catalyst of change

3) *External intervention motivates Informal Processors to formalize by showing the potential for more profits after formalization.*

External intervention implies intervention from NGOs rather than motivation coming internally (within the informal processors). Informal processors can be incentivized in two ways. One way is fear of harassment by law enforcement and monitoring agencies as the informal processing operations are illegal; concern of employees' health. In this way, informal processors reluctantly formalize because they know their profits are going to reduce. A second way is to show the potential for more profits as higher quantity of e-waste can be obtained from new sources and operationally efficient e-waste processing. Formalization will help to avail bank loans for expanding business, the processors can also approach sources directly to procure e-waste and need not buy from scrap dealers, technology or equipment will improve the efficiency of processing operations, etc.

Content of formalization process

4) *Formalization of Informal Processors is done using external help.*

This means that formalization process involves active participating and help from external organizations like NGOs. This because these external organizations are familiar with the

formalization process and can help smoothen the difficulties faced by informal processors while they formalize.

5) *Formalization process involves installing prescribed technology or equipment for processing e-waste and obtaining registration from the respective SPCB.*

The technology (i.e. the process) or the specific equipment that needs to be installed for processing e-waste is specified by the government. Installing them and obtaining registration from State Pollution Control Board constitutes formalization. Doing this eliminates negative externalities to the health and environment. Based on the method of formalization (explained in forthcoming propositions), the details of technology or equipment could differ.

6) a) *There are three methods to formalize: competitive, cooperative, and integrative.*

In 'competitive' method of formalization, informal processor becomes formal and competes with existing formal processors. In 'cooperative' method, informal processor decides to cooperate with other informal processor and jointly become formal. In 'integrative' method, informal processor decides to integrate itself with a large formal processor (Besiou et al., 2012). The informal processor does e-waste collection and simple (non-hazardous) processing operations for the formal processor. The processing operations, which are hazardous and more expensive if the informal processor does it, are done by the large formal processor. What do we mean by a large formal processor? One who has money to invest in expensive processing operations or who already has invested heavily in processing operations.

b) *Informal Processors choose competitive method if economic value, quantity, and frequency of e-waste supply is high.*

If the informal processor was receiving high quantity of high economic value e-waste frequently, she prefers the competitive method because she is able to bear the costs of formalization. For example, if the informal processor was purchasing used computers of IT companies regularly from a scrap dealer (this e-waste has high economic value) she will be making high profits before formalization. She knows that she will consistently get this e-waste from that scrap dealer and she can make more profits after formalizing due to operationally efficient processing and purchasing more such e-waste from the same scrap dealer.

c) *Informal Processors choose cooperative method if economic value, quantity, and frequency of e-waste supply is low.*

This is because the informal processor cannot bear the costs of formalization. She would have been earning meagre profits before formalization due to low economic value, quantity, and frequency of e-waste supply from the scrap dealer.

d) *Informal Processors choose integrative method if economic value is low but quantity and frequency of e-waste supply is high.*

The economic value of e-waste supply is low due to restricted processing that can be done i.e. the informal processor cannot install expensive equipment for extracting precious metals from e-waste. If the quantity and frequency of e-waste supply is high, she can partner with an existing large formal processor and supply the e-waste in return for the expensive processing and share profits.

Outcome of formalization

7) a) *Formalization increases the cost of doing business and this decreases the profits immediately after formalization. But, the performance of processing operations improves and negative externalities are eliminated.*

When the informal processor formalized by purchasing and installing technology or equipment, fixed costs increases immediately (same day and same month). This will decrease immediate profits. But, the efficiency of operations improve i.e. they are able to process more e-waste than before and extract more value. Negative externalities to health and environment are eliminated due to change in processing operations.

b) *In the intermediate stage after formalization, the firm is able to procure more e-waste from new sources.*

After six months (intermediate stage), formalization enables the processor to procure e-waste from new sources directly rather than relying only on scrap dealers i.e. they approach bulk

consumers[22] of e-waste and sign contracts with them for purchasing e-waste. This increases the variety and quantity of e-waste supply.

c) *In the intermediate stage after formalization, the firm is able to get credit from banks to expand business.*

During this intermediate stage, the processor avails bank loans to expand his business or purchasing new equipment for processing or to fund his working capital. These ensure that the profits do not reduce further and improvements in profits are visible.

d) *In the final stage, the firm is able to process more variety and quantity of e-waste efficiently. This leads to improved profits that will be higher than what it could have earned being informal.*

In the final stage (after one year) when the business stabilizes, processor makes more profits than what he could have earned being informal. This is due to operationally efficient process and new sources of e-waste. Otherwise, there is always an option to fall back into rudimentary unsafe processing operations to make profits. The time duration for immediate, intermediate, and final stages are based on Done et al. (2011). These durations are tentative and will be modified based on field data.

e) *The outcomes in immediate, intermediate, and final stages are the same for all three methods of formalization.*

8) *Formalization costs will be lower and profits will be higher in the cooperative method when compared to the competitive method.*

In cooperative methods, informal processors can share the costs of formalization. This reduces the fixed costs and variable costs substantially. In the final stage after formalization, the profits are higher when compared to the competitive method formalization. This is due to economies of scale in collection and processing operations in cooperative method.

[22] These are small organizations or big MNCs like Infosys, Siemens, Honeywell, etc. who dispose their e-waste in large quantities (bulk).

9) *Formalization costs and profits for Informal Processors in integrative method are lower than cooperative method.*

The costs for formalization in the integrative method is less than cooperative method because there are no fixed costs of technology or equipment for processing. Profits are less than that obtained by the competitive method due to the profit sharing agreements and core processing operations done by the formal processor. The formal processor invests in expensive high-tech equipment and extracts value by processing e-waste. He retains a larger share of the revenues or profits and shares a fraction with informal-turned-formal processor. This is based on the contractual agreement between the informal-turned-formal processor and the large formal processor.

10) *Profits of Formal Processors increases in the integrative method due to reduced collection costs.*

The high quantity and frequency of e-waste supply reduces the collection costs of formal processors in the integrative method.

11) *The final profits earned by the informal-turned-formal processor through any of the three methods (competitive, cooperative, integrative) will be higher than what it could have earned being informal.*

Otherwise, there is always an option to fall back into rudimentary unsafe processing operations to make profits.

Controlling for rival explanations

12) *The observed outcomes of informal-turned-formal processors are only due to formalization.*

The outcomes observed in immediate, intermediate, and final stages are only due to formalization process and is not influenced by external market conditions (like high quantity

of e-waste supply due to changes in market), other new practices by the processor that is not linked to formalization, and influence of EMHR that was effective from May 2012.

These 12 propositions are summarized in Table 3, below.

Table 3: Propositions to understand formalization

No.	Proposition	Link to conceptual framework
1	Informal Processors process e-waste without any pollution abatement technology, protective equipment and make profits.	Initial conditions before formalization
2	Informal Processors do not formalize because they perceive formalization to involve higher processing costs and consequently reduced profits.	
3	External intervention motivates informal processors to formalize by showing the potential for more profits after formalization.	Catalyst of change
4	Formalization of Informal Processors is done using external help.	Content of formalization process
5	Formalization process involves installing prescribed technology or equipment for processing e-waste and obtaining registration from the respective SPCB. This eliminates negative externalities.	
6 a)	There are three methods to formalize: competitive, cooperative, and integrative.	
b)	Informal Processors choose competitive method if economic value, quantity, and frequency of e-waste supply is high.	
c)	Informal Processors choose cooperative method if economic value, quantity, and frequency of e-waste supply is low.	
d)	Informal Processors choose integrative method if economic value is low but quantity and frequency of e-waste supply is high.	
7 a)	Formalization increases the cost of doing business and this decreases the profits immediately after formalization. But, the performance of processing operations improves and negative externalities are eliminated.	Outcome of formalization
b)	In the intermediate stage after formalization, the firm is able to procure more e-waste from new sources.	
c)	In the intermediate stage after formalization, the firm is able to get credit from banks to expand business.	
d)	In the final stage, the firm is able to process more variety and quantity of e-waste efficiently. This leads to improved profits that will be higher than what it could have earned being informal.	
e)	The outcomes in immediate, intermediate, and final stages are the same for all three methods of formalization.	
8	Formalization costs will be lower and profits will be higher in the cooperative method when compared to the competitive method.	
9	Formalization costs and profits for Informal Processors in integrative method are lower than cooperative method.	
10	Profits of Formal Processors increases in the integrative method due to reduced collection costs.	
11	The final profits earned by the Informal-turned-formal Processors through any of the three methods (competitive, cooperative, integrative) will be higher than what it could have earned being informal.	
12	The observed outcomes of Informal-turned-formal Processors are only due to formalization.	Controlling for rival explanations

3A.5 Conceptual framework and propositions to understand e-waste RSC

To develop a conceptual framework for the describing the e-waste RSC, we relied on field knowledge gained through the pilot study during April-May 2011. As described in the previous chapter, we are interested to understand the RSC from an industry-level perspective. OM scholars have used such an approach to understand supply chains of various industry contexts. For example, Sinha & Kohnke (2009) studied the supply chain of health care industry using an industry-level perspective. The key questions they studied, are as follows: What are the key industries that are associated with development and delivery of health care? What are the interdependence between these industries? The upstream part of the supply chain (focusing on the development of health care) had industries like biotech, pharma, medical devices; downstream part of the supply chain (focusing on the delivery of healthcare) had industries like hospitals, clinics, hospices, etc. Between them, there was healthcare financing industry that comprised of banks and insurance companies.

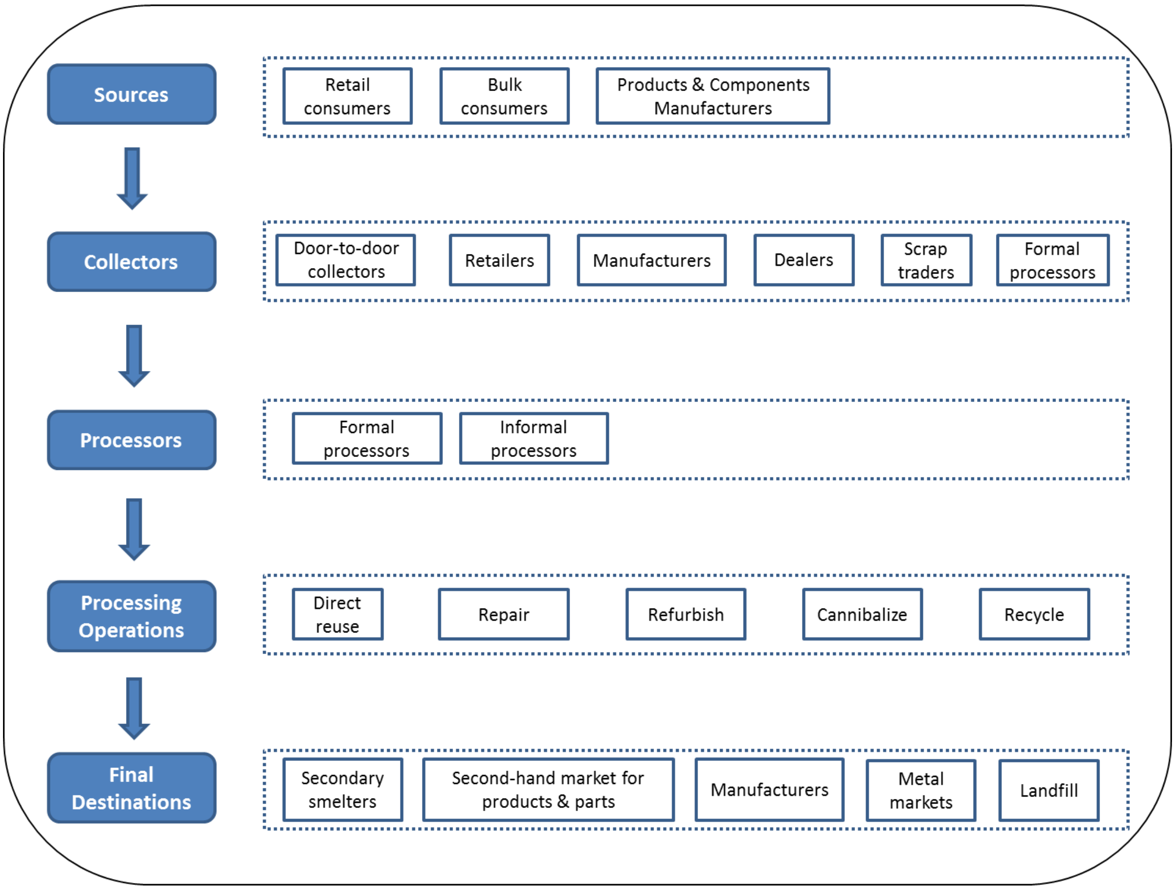
Before developing the propositions for our study, we first describe our understanding of the e-waste RSC. From this understanding, propositions are developed. The case study description starts when consumers dispose e-waste. The consumers are households (which produce e-waste in small quantities) and firms (which produce e-waste in high quantities). Their disposal options are stock-up in warehouses, sell to retailers or scrap dealers or formal processors, return to manufacturers, or combine with municipal waste. The disposal option chosen by consumers depends on some factors. Retailers and scrap dealers sell e-waste to the formal processors, informal processors, or manufacturers for processing. There are five options for processing e-waste: reuse, repairing, refurbishing, cannibalization, and recycling. If products are functional and have high demand in the second-hand market, they will be sold directly in the second-hand market. The functionality is verified using simple inspections or other procedures. This option to sell functional products directly in second-hand market is reuse. If products are not functional or have low demand in the second-hand market, simple disassembly is done and the components are sorted into plastic, metal, and glass fractions. These fractions are sold to secondary smelters. Secondary smelters extract metal from metal scrap. In some situations, the products' components, that are functional, are sold in the spare parts market (if the demand is high) or are used for making new products. For example, computer monitors can be used for making color televisions. Thierry et al. (1995) describe repairing, refurbishing, remanufacturing, and recycling operations. Repairing, refurbishing, and remanufacturing

conserve products' identity and functionality. These operations restore products back to the original condition. Repairing involves replacement of broken parts with limited disassembly and reassembly. Refurbishing involves disassembly of products into modules that are inspected, replaced, and reassembled. This may include replacing outdated modules with technologically superior ones. Quality standards are less rigorous than those for new products. Remanufacturing aims to restore products to the quality level required for new products. Hence, there is complete disassembly, extensive inspection, and technological upgrading. Recycling aims at material recovery and does not conserve products' identity and functionality. This option is chosen if products are not functional or functional products and its components have low demand in the second-hand market. The materials recovered from e-waste are sold in the metal market or to manufacturers. These recovered materials are further used in the manufacture of same or different products. The remaining unprocessed content of e-waste is disposed in landfills. The case study description ends when e-waste reaches second-hand market, new products, smelting plants, or landfill i.e. the immediate stage after processing. The description focusses only on e-waste and does not include municipal solid waste. This description includes the flow of products, information, and money between various stakeholders. The stakeholders include consumers, retailers, scrap dealers, manufacturers, formal processors, informal processors, secondary smelters, etc. This case study description will help us understand stakeholders' perspectives in the e-waste RSC. The theory[23], developed for this descriptive case study, cover the scope (where should the description start, and where should it end?) and depth (what should the description include, and what might it exclude?) (Yin, 2003). This theory specifies the critical ingredients of the phenomenon to be described (Yin, 2003). This helps to structure data collection. MoEF had enacted take-back legislation for e-waste (EMHR). This legislation has been effective from 1st May 2012. The impact of this legislation on the e-waste RSC is not known (there is no published academic literature). Questions on the influence of this legislation are included in the data collection plan. Our hypothesis is EMHR has not caused significant changes in the e-waste RSC. There may be some links in the RSC that were created or destroyed after May 2012. For example, manufacturers collecting e-waste and sending to Formal Processors (by complying with EMHR) would create a new link; Informal Processors not processing e-waste (by complying

[23] The term "theory" denotes the abstract conceptual framework and does not denote any major social science/management theories.

with EMHR) would destroy an existing link in the RSC. Our understanding of e-waste RSC is illustrated in Figure 8.

Figure 8: A conceptual framework of e-waste RSC



This conceptual framework is operationalized into 18 propositions. They are explained below.

Propositions 1, 2, 3, and 4 characterizes sources of e-waste.

1) *Sources of e-waste are retail consumers, bulk consumers, and products & components manufacturers having different purchase and disposal mechanisms.*

This is where case study description starts i.e. when consumers dispose e-waste.

2) *Retail consumers purchase from retailer channels (on-line and off-line) at maximum retail prices in small quantities.*

For example, an individual purchasing mobile phone, television, etc. from a retailer is a retail consumer. Households can also be considered as retail consumers. Retail consumers also purchase products at less than maximum retail prices due to retailers' discounts and other offers. But, there is no price negotiation or contract between retail consumer and retailer. Retail consumers purchase electrical and electronic products, consume them, and discard them at the end-of-use or end-of-life (which is then called e-waste).

3) *Bulk consumers purchase from dealers, authorized by manufacturers/importers, in large quantities through some contracts.*

Organizations that purchase computers and accessories from authorized dealers in large quantities (like 1,000 units, 10,000 units, etc.) are bulk consumers. In these cases, a special price is negotiated between the dealer and organization. Typically, these products are used for organizational purposes and cannot be owned by individuals (employees) in the organization.

4) *Products & components manufacturers of electrical and electronic products produce defective products that enter e-waste stream.*

Manufacturers of various electrical and electronic products produce defectives (items that do not meet quality requirements) due to issues in manufacturing or design. These defectives are also e-waste as it cannot be used or repaired by manufacturers.

5) *a) The economic value of products discarded by consumers (retail and bulk consumers) depends on its functionality, demand in second-hand market, design modularity.*

By economic value, we mean monetary value i.e. money that can be obtained by discarding the product. It is commonly known that the economic value of discarded products (in the reverse supply chain) cannot be higher than its retail price (in the forward supply chain).

b) *Functional products have higher economic value than non-functional products.*

Functional means the product delivers its originally intended functions. For example, a functional television discarded by retail consumer fetches more money than a functionally

‘dead’ television i.e. generally, end-of-use products have higher economic value than end-of-life products.

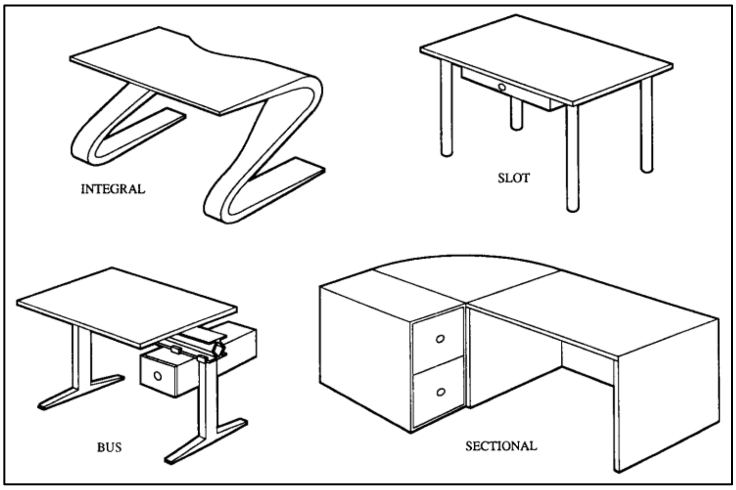
c) *Functional products with high demand in second-hand market have higher economic value than functional products with low demand in second-hand market.*

For example, functional telephones with rotary dials have low demand in second-hand market when compared to functional mobile phones. Generally, low demand of a product in second-hand market is due to its obsolescence.

d) *Products with high design modularity have higher economic value than products with low design modularity.*

By design modularity, we mean modularity in design and not modularity in manufacturing. There is no standard definition for design modularity in operations management (Fixson, 2007). Scholars have used definitions of Ulrich (1995) and Baldwin & Clark (1997, 2000) for design modularity. According to Baldwin & Clark (1997, 2000), a modular product is “composed of units (or modules) that are designed independently but still function as an integrated whole”. Partitioning design information into visible design rules and hidden design parameters is necessary to achieve modularity. Visible design rules consist of three elements: architecture, interfaces, and standards. Architecture specifies what modules will go into the product and functions of each module. Interfaces describe how the modules will fit together, connect, and communicate. Standards consist of rules for testing modules’ conformity to design rules and for measuring performance of modules relative to another. Hidden design parameter affects only the local module and has no influence on the overall product design. Hidden design parameters are not required to be known for fitting, connecting, communicating different modules. With this definition, Apple computer/laptop is less modular than Lenovo computer/laptop because the design rules of Apple are not visible. According to Ulrich (1995), a modular product has two characteristics (1) one-to-one mapping between functional elements and physical components (2) de-coupled interfaces between components. Ulrich (1995) illustrates his idea using an example of a desk. This is illustrated in Figure 9 (adopted from Ulrich, 1995).

Figure 9: Illustration of design modularity



In the integral design of desk, the mapping between functional elements and physical components is not one-to-one and interfaces between components are not de-coupled. The other three desk architectures (slot, sectional, and bus) have modular design i.e. physical components (e.g., table top, legs, etc.) can be de-coupled and each physical component has one-to-one mapping with its intended function. We use Ulrich' basic definition because it is more appropriate for our study. Products that are 100 percent integral or modular is possible only in an ideal world. In reality, there are gradations of modularity i.e. some products are more modular than others. With increasing modularity, it is easy to disassemble and take valuable parts out or repair and reassemble (Fernandez & Kekale, 2005; Newcomb et al., 1998). For example, consider televisions and computers with modular designs. They can be disassembled, repaired, and reassembled with ease. Thus, products with high design modularity have higher economic value than products with low design modularity. We could have also included concepts like modularity-in-use and come up with some propositions. We could also have used Baldwin & Clark's (1997, 2000) definition of design modularity. But, we decided to stick to Ulrich (1995) to develop the bare-bone proposition. We may get more information on whether modularity is actually important or how important from the field. It can also happen that, based on field data, we may have to revise the definition and include modularity-in-use or use Baldwin & Clark (1997, 2000). The purpose here is only to develop a very basic proposition which will help us to look for evidence on modularity.

Propositions 6, 7, 8, and 9 characterizes disposal mechanisms of e-waste sources.

6) a) *Retail consumers have six options to dispose e-waste: stock-up at home, sell to door-to-door collectors, sell to retailers, give to formal processors, return to manufacturers, or combine with municipal solid waste.*

We propose that retail consumers have only these six options to dispose their e-waste. The conditions for choice of a disposal option is proposed in the following propositions. Door-to-door collectors means rag-pickers/scavengers (they are popularly called *kabadiwallas* in India) who visits households and purchases e-waste by paying money or otherwise. For example, a household gives away used keyboards, electronic toys, etc. to the door-to-door collector for a price or free of cost.

b) *Low volume products with low economic value are stocked at home or disposed along with municipal solid waste.*

Low volume products are easier to be stocked at home. If the economic value of these products is negligible, there are no incentives for retail consumers to sell to other collectors. Some examples are bulbs, tube lights, batteries, etc.

c) *Low volume products with high economic value are stocked at home or sold to retailers.*

Low volume products are easier to be stocked at home and can be transported easily. If the economic value of these products is high, it can be carried to retailers and sold. Some examples are end-of-use mobile phones, end-of-use laptops, etc. The stocking behavior of these products (in spite of high economic value) is due to behavioral reasons. We do not get into the behavioral decision making literature because we are more interested in breadth (to map the RSC of e-waste) rather than depth (consumer disposal behavior).

d) *High volume products with high economic value are sold to door-to-door collectors or retailers.*

It is easier and economical to sell products like refrigerators, televisions, and personal computers to door-to-door collectors rather than taking them to retailers and selling it i.e. it is more profitable to sell used television to a door-to-door collector rather than retailer assuming both collectors pay the same price. One could argue that high volume products are also stocked

at home. But, high volume products takes up more space and is difficult to stock them for a long time (due to storage space limitations) when compared to low volume products.

7) a) *Bulk consumers have six options to dispose e-waste: stock-up at warehouse, conduct auctions, contract with scrap dealers, contract with formal processors, return to dealers, or combine with municipal solid waste.*

Formal processors incur high set-up and operating costs and cannot match the price paid by scrap dealers who incur low set-up and operating costs. Formal processor always quote a lower price than scrap dealers for e-waste. Hence, bulk consumers do not get higher payment from formal processors.

b) *Products with low economic value are stocked at warehouses or disposed along with municipal solid waste; products with high economic value are auctioned openly or contracted with scrap dealers.*

Bulk consumers prefer to sell products with high economic value to scrap dealers through contracts because they pay higher than formal processors. Choosing an open auction means that both formal processors and scrap dealers are invited. In open auctions, scrap dealers always quote a higher price than formal processors and purchase e-waste.

8) *Products & components manufacturers destroy their defective products to prevent it from entering the market and then sell to scrap dealers.*

Manufacturers protect their brand and do not let their defective products enter the market to be sold for reduced prices. They destroy these products by crushing or disassembling and sell to scrap dealers.

9) *Retailers collect functional and non-functional products only from retail consumers through buy-back and exchange schemes.*

For example, retail consumers purchase new mobile phones, televisions, etc. by exchanging their used mobile phones, televisions.

Propositions 10, 11, and 12 characterizes mechanisms through which e-waste finally reaches processors (formal and informal).

10) *Retailers and dealers sell e-waste only to scrap dealers because they receive higher payment.*

Retailers collect e-waste from retail consumers and dealers collect e-waste from bulk consumers. Retailers and dealers have no incentive to sell to formal processors because they pay lower amount than scrap dealers.

11) *Scrap dealers aggregate the collected e-waste up to an appropriate quantity and sell them to informal processors.*

Scrap dealers collect e-waste and aggregate them till it reaches an appropriate quantity. The aggregation is needed to achieve economies of scale in transporting the e-waste to informal processors.

12) *Manufacturers with take-back systems/collection systems sell the collected e-waste to formal processors; manufacturers do not own e-waste processors facilities.*

For example, though Nokia collects e-waste through collection bins it does not own processing facility (Sohail, 2013). The collected e-waste is sold to a formal processor.

Propositions 13 to 15 describes the various processing operations, factors that affect choice of processing operations, and final destinations of e-waste.

13) a) *Informal and formal processors have five options for processing e-waste: direct reuse, repairing, refurbishing, cannibalization, and recycling.*

The options of processing e-waste are abstracted from Thierry et al. (1995). What follows is based on the description provided by Thierry et al. (1995). If used products are functional and have high demand in the second-hand market, they will be sold directly in the second-hand market. The product functionality is verified using simple inspections or other procedures. This option to sell functional products directly in second-hand market is <u>direct reuse</u>. Repairing,

refurbishing, and remanufacturing involve upgrading used products with respect to quality or technology or both. Repair involves low level of upgrading and remanufacturing involves high level of upgrading. Repairing involves fixing/replacement of broken parts only. Other parts are not affected. There is limited product disassembly and reassembly. Generally, the quality of repaired products is lower than the quality of new products. Refurbishing involves disassembly of used products into modules. Critical modules are inspected and fixed/replaced. Outdated modules and parts are replaced with technologically superior modules and parts. Though refurbishing brings used products up to a specified quality level, the quality level specified is lower than the quality of new products. Refurbishing improves product quality and extends its life. Repairing, and refurbishing conserve products' identity and functionality. These operations restore used products back to the original condition. Cannibalization involves recovering a limited set of reusable parts from used products i.e. selective disassembly of used products and inspection of parts that are potentially reusable. These parts are used for repairing, refurbishing, of other products. Cannibalization restores the identity and functionality of parts. Recycling involves at material recovery from used products and parts and does not conserve products' identity and functionality. The materials recovered are used in the production of original products or other products or sold to other companies.

There is one more processing operation, apart from repairing and refurbishing, that conserves product identity and functionality. This is remanufacturing and involves complete disassembly of used products and extensive inspection of all modules and parts. Worn-out and outdated modules and parts are replaced with new modules and parts. Repairable modules and parts are fixed/replaced and tested extensively. Remanufacturing can be combined with technological upgrading of modules and parts. Remanufacturing brings used products up to quality levels specified for new products. Remanufactured products are sold at a lower price than new products. Typically, remanufacturing is done only by manufacturers because it requires an intimate knowledge of the product and manufacturing process. In our case, we hypothesize that formal and informal processors do not possess this intimate knowledge and cannot do remanufacturing operation.

b) *Functional products having high demand in second-hand market are directly reused and sold to channels in second-hand market; functional products having low demand in second-hand market are cannibalized or recycled.*

For example, monitors are carefully disassembled from computers and used for manufacturing television sets. This is cannibalization. The plastic casing of computers are carefully disassembled and sent to plastic smelters for material recovery. This is recycling.

c) *Non-functional products with high design modularity, high demand in second-hand market, and whose functionality can be restored are repaired or refurbished.*

It is easy to disassemble, repair, refurbish, and reassemble products with high modularity (Fernandez & Kekale, 2005; Newcomb et al., 1998). It does not make economic sense to cannibalize or recycle because of the high demand for products in second-hand market and possibility to repair or refurbish. Repaired or refurbished products have higher economic value than cannibalization or recycling. For example, a non-functional computer with a problem in hard disk is repaired rather than cannibalized or recycled.

d) *Repairing is preferred for low functionality loss and refurbishing is preferred for high functionality loss*.

Repairing and refurbishing involve upgrading used products with respect to quality or technology or both. Repair involves low level of upgrading and refurbishing involves high level of upgrading. Low level of upgrading is required for low (less severe) functionality loss and high level of upgrading is required for high (more severe) functionality loss.

e) *Non-functional products with high design modularity and whose functionality cannot be restored are cannibalized for using its parts as spares or inputs to other products.*

This is irrespective of demand for its parts in the second-hand market. In fact, we hypothesize that there is always some demand for parts inside any electrical and electronic product. If it is possible to easily disassemble the product, parts are retrieved for storing it as spares or for using it in other products.

f) *Functional products with low design modularity and low demand in second-hand market are recycled; functional products with high design modularity and low demand in second-hand market are cannibalized.*

If there is low demand in second-hand market and low design modularity, it is more expensive (difficult) to disassemble the product and cannibalize parts. Hence, the processor can make more money by material recovery. In the case of high design modularity, it is less expensive (easy) to disassemble and cannibalize.

g) *Non-functional products with low design modularity and high demand in second-hand market are recycled.*

If products have low design modularity, it is difficult to disassemble, repair, and reassemble the product. Thus, it is also difficult to cannibalize. The only option that remains is recycling.

h) *Unprocessed portion of products is disposed in landfills.*

The portion of products that are not economical valuable (due to difficulty in processing or low market demand) are not processed. These portions are disposed in landfills.

14) *a) A single processor (informal or formal) does all the five processing operations: direct reuse, repairing, refurbishing, cannibalization, and recycling.*

b) *Processors (informal or formal) do selective recycling operations*.

Though processors engage in some recycling like recovery of precious metals from circuit boards, they do not do recycling to the fullest extent. For example, the plastic parts of products are sold to plastic smelters for material recovery.

c) *Informal processors incur lower costs and produces lower quality output when compared to formal processors.*

For example, if an informal processor incurs Rs. X and can extract a metal (say copper) with Y% impurity a formal processor incurs Rs. (X + some positive value) and can extract a metal with (Y- some positive value)% impurity.

15) *Negative externalities are created by informal processors during the five processing operations on all types of products and landfilling; formal processors do not create*

negative externalities during the five processing operations on all types of products and landfilling.

Formal processors have installed the technology/equipment needed for safe processing and landfilling and informal processors do not have this technology/equipment. Formal processors are authorized by the Government to process e-waste because they have installed the prescribed technology/equipment.

Propositions 16 to 18 capture the general structure of e-waste RSC and influence of EMHR.

16) *Retailers, dealers, manufacturers, informal processors, formal processors, scrap dealers, secondary smelters are individual profit-maximizing stakeholders in the e-waste RSC.*

This means these stakeholders are individual entities who are interested in maximizing their own profits. For example, scrap dealers do not own informal processing facilities, informal processors do not interact with formal processors.

17) *The e-waste RSC structure is decentralized and open-loop.*

The concepts of decentralization and open-loop are explained by Fleischmann et al. (2000). Decentralization means that activities in RSC like e-waste collection, processing operations are carried out in more than one location in parallel. For example, refurbishing operation is done by processors in Bangalore, Chennai, and Delhi. It is not that a single processing operation is done only in one location. Open-loop means that 'sources' and 'sink' in the e-waste RSC do not coincide. The outputs from e-waste processing enter into different products and different set of consumers. For example, the plastic parts of e-waste are recycled and the recovered plastic is used for making carpets and buckets.

18) *EMHR has not caused significant changes in the e-waste RSC. There may be some links in the RSC that were created or destroyed after May 2012.*

EMHR was notified in 2011 and effective from May 2012. The legislation mandates manufacturers of specific products in IT and consumer electronics to establish collection

systems and ensure safe processing of e-waste by selling to formal processors. We hypothesize the e-waste RSC (which existed before EMHR) to persist even after EMHR is in place. This is due to poor institutional enforcement and monitoring of EMHR and lack of incentives for stakeholders in e-waste RSC to comply with EMHR. Though EMHR was superseded in 2016, we use EMHR 2011 for the purpose of evaluating this proposition. The 2016 supersession of EMHR appeared during the completion of our fieldwork. Hence, unless specified otherwise, EMHR denotes 2011 notification. A copy of EMHR 2011 and 2016 is included in Appendix6 and Appendix 7, respectively.

These 18 propositions are summarized in Table 4.

Table 4: Propositions to understand e-waste RSC

No.	Propositions	Link to e-waste RSC
1	Sources of e-waste are Retail Consumers, Bulk Consumers, and Parts & Component Manufacturers having different purchase and disposal mechanisms.	Sources of e-waste
2	Retail Consumers purchase from retailer channels (on-line and off-line) at maximum retail prices in small quantities.	
3	Bulk Consumers purchase from dealers, authorised by manufacturers/importers, in large quantities through some contracts.	
4	Parts & Component Manufacturers of electrical and electronic products produce defective products that enter e-waste stream.	
5 a)	The economic value of products discarded by consumers (Retail and Bulk Consumers) depends on its functionality, demand in second-hand market, design modularity.	Disposal mechanisms of e-waste sources
b)	Functional products have higher economic value than non-functional products.	
c)	Functional products with high demand in second-hand market have higher economic value than functional products with low demand in second-hand market.	
d)	Products with high design modularity have higher economic value than products with low design modularity.	
6 a)	Retail Consumers have six options to dispose e-waste: stock-up at home, sell to door-to-door collectors, sell to retailers, give to formal processors, return to manufacturers, or combine with municipal solid waste.	
b)	Low volume products with low economic value are stocked at home or disposed along with municipal solid waste.	
c)	Low volume products with high economic value are stocked at home or sold to retailers.	
d)	High volume products with high economic value are sold to door-to-door collectors or retailers.	
7 a)	Bulk Consumers have six options to dispose e-waste: stock-up at warehouse, conduct auctions, contract with scrap dealers, contract with formal processors, return to dealers, or combine with municipal solid waste.	
b)	Products with low economic value are stocked at warehouses or disposed along with municipal solid waste; products with high economic value are auctioned openly or contracted with scrap dealers.	
8	Parts & Component Manufacturers destroy their defective products to prevent it from entering the market and then sell to scrap dealers.	
9	Retailers collect functional and non-functional products only from retail consumers through buy-back and exchange schemes.	
10	Retailers and dealers sell e-waste only to scrap dealers because they receive higher payment.	Mechanisms through which e-waste finally reaches e-waste processors (formal and informal)
11	Scrap dealers aggregate the collected e-waste up to an appropriate quantity and sell them to informal processors.	
12	Manufacturers with take-back systems/collection systems sell the collected e-waste to formal processors; manufacturers do not own e-waste processors facilities.	
13 a)	Informal and Formal Processors have five options for processing e-waste: direct reuse, repairing, refurbishing, cannibalization, and recycling.	
b)	Functional products having high demand in second-hand market are directly reused and sold to channels in second-hand market; functional products having low demand in second-hand market are cannibalized or recycled.	

c)	Non-functional products with high design modularity, high demand in second-hand market, and whose functionality can be restored are repaired or refurbished.	Various processing operations, factors that affect choice of processing operations, and final destinations of e-waste
d)	Repairing is preferred for low functionality loss and refurbishing is preferred for high functionality loss.	
e)	Non-functional products with high design modularity and whose functionality cannot be restored are cannibalized for using its parts as spares or inputs to other products.	
f)	Functional products with low design modularity and low demand in second-hand market are recycled; functional products with high design modularity and low demand in second-hand market are cannibalized.	
g)	Non-functional products with low design modularity and high demand in second-hand market are recycled.	
h)	Unprocessed portion of products is disposed in landfills.	
14 a)	A single processor (informal or formal) does all the five processing operations: direct reuse, repairing, refurbishing, cannibalization, and recycling.	
b)	Processors (informal or formal) do selective recycling operations.	
c)	Informal Processors incur lower costs and produces lower quality output when compared to formal processors.	
15	Negative externalities are created by Informal Processors during the five processing operations on all types of products and landfilling; Formal Processors do not create negative externalities during the five processing operations on all types of products and landfilling.	
16	Retailers, dealers, manufacturers, informal processors, formal processors, scrap dealers, secondary smelters are individual profit-maximizing stakeholders in the e-waste RSC.	General structure of e-waste RSC and influence of EMHR
17	The e-waste RSC structure is decentralized and open-loop.	
18	EMHR has not caused significant changes in the e-waste RSC. There may be some links in the RSC that were created or destroyed after May 2012.	

In this chapter, we justified the use of qualitative case study as appropriate to answer the research questions. We also discussed the philosophical underpinnings (orientations) of various approaches to case study and finally decided on using Yin's approach. Based on this, we developed conceptual frameworks and propositions to understand formalization and e-waste RSC. In the next chapter, we explain how data/evidence was collected and analyzed.

Chapter 3B: Data Collection & Analysis

In Chapter 3A, we developed the conceptual framework and propositions to guide data/evidence collection and analysis. In this chapter, we explain the process of how data[24] was collected and analyzed. This consists of the following steps:

- ✓ Decide the unit of analysis
- ✓ Design the questionnaire: structure and wording of questionnaire
- ✓ Data collection from primary sources
- ✓ Data collection from secondary sources
- ✓ Data analysis

3B.1 Decide the unit of analysis

Formalization process: Informal-turned-formal processor is the unit of analysis i.e. case. We used multiple cases in this study. The multiple case design is akin to running a series of experiments (one case is one experiment) where each case serves to confirm or disconfirm the inferences drawn from previous cases (Yin, 2009). Yin (2009) calls this embedded multiple-case design.

Structure of e-waste RSC: Unit of analysis (i.e. case) is the e-waste RSC. This is the level at which we want to describe our findings. Data from multiple sites (i.e. units of data collection) will be used to aggregate to the level of e-waste RSC. Yin (2009) calls this as embedded single-case design.

3B.2 Design the questionnaire: structure and wording of questionnaire

It is necessary to understand the nature of potential respondents, before designing the questionnaire. Hence, we first discuss sample frame (who the potential respondents would be) and then explain questionnaire design.

Formalization process: The important concepts that impact formalization of informal e-waste processors can be only known from the founders of informal-turned-formal firms and experts

[24] Data denotes qualitative data (i.e. textual data) and not numerical data. The two terms "data" and "evidence" are synonymously used in this dissertation.

from NGOs who have been involved in the formalization process. Hence, interviews with such stakeholders are the primary source of evidence. Founders or employees of informal-turned-formal processors, change agents from NGOs or other organizations (if any) who were involved in formalizing the informal processors, and Government officials granting authorization to processors were interviewed. The details regarding respondents and how they were selected is explained in the forthcoming section.

Structure of e-waste RSC: The important variables that characterize RSC can be only known from experts who are knowledgeable about the e-waste RSC because there is little prior knowledge. They are individuals who are working or have worked in organizations related to e-waste awareness, processing, collection, law enforcement, etc., for a reasonable time duration. Hence, interviews with experts are the primary source of data for our study. These experts from different or same organizations would view the e-waste RSC from diverse perspectives.

Initial structure of inquiry[25]

Stakeholders were subjected to interviews using guided conversations rather than structured queries (Yin, 2009). Guided conversations would enable stakeholders' responses not to be influenced by what the interviewer expects them to say. We prepared a set of questions that form the structure of inquiry. The form of actual interview questions were open-ended because we were interested to know stakeholders' understanding and perspectives. We started the actual conversational questions in a broad manner and from the responses to these broad questions, further progressively focused questioned were asked. Sekaran and Bougie (2009) calls this transition from broad to narrow questions as *funneling technique*. This technique enables the expert (respondent) to perceive himself as the 'master' and the interviewer (researcher) as 'novice'. The funneling technique combined with open-ended questions would enable interviewees (respondents) to reveal their true understanding of the focal phenomenon and their responses will not influenced by what the interviewer (researcher) expects them to say. Yin (2009) defines the actual conversational questions as Level 1 questions and the set of questions that form the structure of inquiry as Level 2 questions. Level 2 questions are not the actual conversational questions. Rather, questions in Level 2 provide focus to the interviewer (i.e. the

[25] Structure of inquiry denotes the questionnaire.

researcher) on what information needs to be collected. The questions in Level 2 are derived from the conceptual framework. Level 1 questions are posed by the interviewer (i.e. the researcher) to specific interviewees. These are specific questions that help to obtain the required information identified by Level 2 questions. Both levels of questions are listed in Table 5, Table 6 for understanding formalization and e-waste RSC.

Table 5: Initial structure of inquiry to understand formalization

Propositions and stages in formalization	**Level 2**	**Level 1**
1,2,6 Initial conditions	What was the condition before formalization? - Sources of e-waste - Kinds of e-waste processed - Supply uncertainty, quality, and quantity of e-waste - Processing operations and negative externalities - Technology used, fixed costs, variables costs, inputs and outputs. - Profits Why did the firm remain informal? - Exclusion view - Exit view	What is e-waste? Can you give some examples? I am interested to know about the firm's condition before formalization: -What were your sources of e-waste? -What kinds of e-waste did you source? -How were you processing it? -How was the business running? Why did you run business informally?
3 Catalyst of change	Event or development moving the firm to pursue formalization What was the motivation for formalization? - Positive incentives - Negative incentives Motivation came internally or externally?	How did you decide to formalize? Did anyone play an important role? What was their role?
4, 5, 6, Formalization process	-Was there any external help? How did they help? -What was the method of formalization? -Methods of formalization: Competitive, Cooperative, Integrative -How did they decide the method? -Content of formalization? Changes in processing operations i.e. technology used, fixed costs, variable costs, inputs and outputs. Changes in non-processing operations	What happened in the formalization process? Who were involved? How did they involve? What actions did you take to formalize? How?

7a,7e, 8, 9, 10, 11 Immediate outcome	What was the immediate outcome? - Improved performance of processing operations? How?	How was your business experience immediately after formalization? How was the change in processing operations?
7b, 7c,7e, 8, 9, 10, 11 Intermediate outcome	What was the intermediate outcome? - New sources of e-waste? - Kinds of e-waste processed?	What were your sources of e-waste after formalization? Any new sources? What kinds of e-waste you processed after formalization? Was this better than before?
7d,7e, 8, 9, 10, 11 Final outcome	What was the final outcome? - Profits? - Supply uncertainty, quality, and quantity of e-waste?	How is the business running now?
12 Rival explanations	1) Other new practices by firm 2) External market conditions 3) E-waste Rules 2011	1) Apart from formalization related process change, any other new changes were made? 2) Quantity and sources of e-waste increasing every year? Competition from other recyclers? 3) Government has enacted the e-waste legislation. How is your business experience?

Table 6: Initial structure of inquiry to understand e-waste RSC

Propositions and stages in the RSC	**Level 2 questions**	**Level 1 questions**
1,2,3,4,5,6,7,8,9 Consumers or sources	-What are the different sources of e-waste? -Do they purchase differently? -How is e-waste disposed by retail consumers, bulk consumers, and manufacturers? -Are there other sources of e-waste? How do they dispose e-waste? -What disposal options do they have? -How do they decide a particular disposal option? -Is there a relation between type of products and the disposal option? What is that relation? -Products, information, and funds flow during disposal?	What is e-waste? Can you give some examples? What are the different sources? How do they dispose? Are all kinds of e-waste disposed the same way?
10,11,12 Collectors	-How do retailers, manufacturers, formal recyclers, and scrap dealers collect e-waste from different types of consumers? To whom do they sell after collection? Why? -Are there other collectors? How do they collect? To whom do they sell after collection? Why?	Who takes the e-waste from consumers after it is disposed? What they do with it after collecting? Is this same for all kinds of e-waste?

	-Products, information, and funds flow?	
10,11,12,16 Processors	-How do formal recyclers and informal recyclers collect e-waste from collectors? -Are there other processors? How do they collect? -Is there any interaction between formal and informal recyclers? Why? -Products, information, and funds flow?	What happens next? How does the transaction happen? What they do with e-waste? Is this same for all kinds of e-waste?
13,14,15 Processing operations	-The six e-waste processing operations -Are there other processing operations? What are they? -How do the processors choose a particular processing operation for a product? -Which processing operations of informal recyclers create negative externalities? Why? -Do processing operations of formal recyclers create negative externalities? Why? -Formal processors: The specific technology used, fixed costs, variable costs, inputs and outputs? -Informal processors: The specific technology used, fixed costs, variable costs, inputs and outputs? -Specialization in processing operations? -Products, information, and funds flow?	What happens next? What they do with e-waste? How? Are all kinds of e-waste processed in the same way? Do all recyclers perform all processing operations? How is the natural environment related to processing operations?
13,17 Final destinations	-How e-waste parts/materials reach secondary smelters, secondary markets, manufacturers, and metal markets after processing? -Are these materials used in the manufacture of same products to same set of consumers? -Products, information, and funds flow?	What happens next? How does the transaction happen? What they do with it?
17,18 General	-Are the activities in the RSC decentralized? Why?	-Is the RSC described same throughout India? -Any activities that happen only in a particular region?
	-How did EMHR 2011 impact this RSC? -New links created? Old links destroyed? -The experience of interviewee as a stakeholder in the RSC?	The e-waste legislation has been effective from May 2012. How was the experience?

Face validation

This initial structure of inquiry was face validated with six research scholars. They are doctoral candidates who have successfully cleared the comprehensive exams after coursework. It is not possible for get face validity from the field, because a single respondent cannot answer all the questions. Moreover, we would lose one data point, if we try doing this. The research scholars

with whom we did face validity test are familiar with our research and knows that a single respondent cannot answer all the questions. So, they imagined themselves in the shoes of potential respondents wherever the questions are applicable and then judged if it would make sense to them. There was disciplinary variation among these six research scholars: 2 from marketing, 3 from operations management, 1 from quantitative methods. All of them were familiar with the nature of qualitative research through their doctoral coursework. The guidelines for pre-testing were: (a) will the interviewee be able to understand the questions? i.e. does the questions mean to him, what we want it to mean? (b) questions should not be leading i.e. it should not make it easier or more tempting for the interviewee to give one answer than another (c) questions should be non-threatening (d) questions should be open i.e. it establishes the topic for the interviewee to respond and leaves her to structure the response as she sees fit. Response from six research scholars were positive, with respect to the above guidelines. Following were the modifications made in the questionnaire based on the feedback from the six research scholars.

- To capture proposition 17 of the e-waste RSC structure, we had this question: "How about any activities that occur only in a particular geographical region?" This question was mentioned as not easy to understand and complex. Hence, this question was modified to this form: "Are there any activities, processing operations that occur only in a particular city or region?" This was regarded as better.

- To capture proposition 12 of the formalization process, we had this question "Generally, how has been the quality and quantity of e-waste every year? Any general trends?" This question was mentioned as not linked to formalization i.e. it did not match with the objective of the proposition. Hence, this question was modified to this form: "After formalization, has there been any general trends, market trends, on quantity or kinds of e-waste every year?" This was regarded as better.

- For e-waste RSC structure, we had this question: "How does the transaction happen?" This question was mentioned as ambiguous and did not match with the objective. The expert can answer this as cash/card/cheque transaction, which was not our objective. Hence, it was changed to this form: "How does the transaction happen? i.e. What materials or products are disposed? At what prices? How are these prices determined?" This was regarded as better.

- To capture proposition 18 of the e-waste RSC structure and proposition 12 of formalization process, we had this question: "The e-waste legislation has been effective from May 2012. How was your experience?" But, will the expert know about this legislation? We may sound authoritative by talking this way. Also, we cannot ask the interviewee if he is aware of the e-waste legislation. That will be like testing his general knowledge. Hence, it was changed to "How was your experience regarding the recent e-waste legislation?" This was regarded as better.

- For the study of formalization process, we had this question: "How was the firm's condition before formalization?", "How is the business now?" This question was mentioned as ambiguous and did not match with the objective. These were modified to this form: "How did the firm function before formalization?", "How does the firm function now?".

- For the study of formalization process, we had this question: "What changes were made in the firm apart from formalization related changes?" This was modified to this form: "Were there any changes made in the firm, apart from formalization related changes?"

- For the study of formalization process, we had this question: "What happened in the formalization process?" This was modified to "What happened in the formalization process? Could you please explain the entire formalization process?"

These modifications were incorporated in the structure of inquiry and we began the fieldwork. But, this structure of inquiry again needed revision based on the initial field visits with a Retailer, Bulk Consumer, NGO, and interaction with few Informal Processors and Informal-turned-formal Processors during a stakeholders' meeting.

Revision of initial structure of inquiry

In this section, we explain what kind of revisions were needed and why. For example, the Retailer could only talk about *what goes on* in her organization. Similarly, the Bulk Consumer was more comfortable talking about what happens in her organization rather than talking broadly about e-waste. So, we had to modify the structure of inquiry. There were no major modifications in Level 1 questions. The Level 1 questions in the initial structure of inquiry was

re-worded in a way that will suit any stakeholder in the RSC. For example, if the question in the initial structure of inquiry was: "What kinds of e-waste are generated by these sources?", we had to ask: "What kinds of e-waste does the organization generate?". Similarly, the question in the initial structure of inquiry: "How is e-waste generated i.e. sources of e-waste?" becomes redundant because we were interviewing a respondent from an organization that we consider to be one of the sources of e-waste. This necessitated the following revisions: (a) Use the initial structure of inquiry to respondents who know about end-to-end RSC like respondents from NGOs, policy think-tanks, Government organizations, etc. (b) Revise the initial structure of inquiry to the level of individual stakeholders in the RSC.

We had conceptualized this RSC into four stages: Sources, Collectors, Processors, and Final Destinations (Figure 8). Within each stage there are various stakeholders. For example, within sources stage, there are Bulk Consumers, Retail Consumers, and PCMs (Products & Components Manufacturers). The conceptualization of RSC into stages/stakeholders was done to facilitate the data collection process. The structure of inquiry which we initially developed had questions that covered propositions within all the four stages and also between stages. Suppose, there are 10 respondents. Following are some of the possibilities:

- All 10 respondents know about all the stages
- 6 respondents know about, say, stage 1 and stage 2; 4 respondents know about, say, stages 3 and 4.
- 6 respondents know about, say, stages 1 and 4; 4 respondents know about, say, stages 1 and 3.
- 3 respondents know about stage 1; 2 respondents know about stage 2; 4 respondents know about stage 3; and 1 respondent know about stage 4.

So, all respondents need not know about all the stages in RSC. The respondents can be stakeholders of any of the stages or they can even be NGOs/Government officials who may know a part or whole of this RSC based on their experience. We need to get their different perspectives to *paint the whole canvas* of RSC. For those respondents who are stakeholders in the RSC, we cannot use the Level 1 questions that were initially developed. We needed to modify the Level 1 questions based on which stage the stakeholder is in. So, after asking the modified Level 1 questions to the stakeholder, we can also ask in general about the RSC using the initial Level 1 questions. So, only the Level 1 questions were modified. The Level 2 questions and propositions remained the same. Based on the initial interviews, we realized that

concepts like changes in product design, declining recycling value of products, etc. influenced this industry. So, questions regarding these concepts were added while revising the initial structure of inquiry.

During these initial interviews, we also realized that Scrap Traders, Informal Processors, Informal-turned-formal Processors are comfortable to interact in Hindi and not English. All of them (during initial interviews) belonged to Muslim community that spoke a particular dialect of Hindi called *Dakhini* (a form of Urdu with a mix of Hindi and the respective language of the State)[26]. This is also called as Hyderabadi Hindi. The researcher's[27] mother tongue is Malayalam, was born and educated for 22 years in Kerala. The researcher has a working knowledge of Hindi. Apart from studying Hindi till Class 8, the researcher has also passed the Prathamik and Madhyama examinations conducted by Dakshin Bharath Hindi Prachar Sabha. Based on the researcher's working knowledge of Hindi, the modified Level 1 questions were translated to Hindi and were pre-tested with two research scholars who were native Hindi speakers. Both of them were familiar with the nature of qualitative research and had credited the doctoral course on qualitative research methods. One of them was from operations management and another was from strategy. Most importantly, both of them knew Urdu and Hindi. One hails from Madhya Pradesh and another from Lucknow. The translated questions were tested to see if it fits with conversational Hindi. Also, they were briefed about the phenomena and various stakeholders (scrap traders, processors, etc.) so that they can assume stakeholders' role and see if the questions made sense. Based on their inputs, the words were modified. For example, we used a proper Hindi word for translating the word 'change'. We initially wrote as 'parivartan'. But, we received feedback saying this is not of conversational nature. It was also said that 'change' (in English) is commonly understood by Hindi speakers. Another word, 'badlaav' instead of 'parivartan' was suggested. Similarly for 'sources', rather than using pure Hindi words like 'sroth', other words like 'jagaaon', 'aaghazh' (Urdu word) were suggested. Similarly, for 'materials', rather using a pure Hindi word 'saamagri', words like 'item', 'cheez' were suggested.

The revised structure of inquiry is explained in Table 7 (formalization), Table 8 (for stakeholders who are familiar with the entire RSC), and Table 9 (for stakeholders who are

[26] I thank my colleague and fellow research scholar, Althaf Shajahan, for this information.
[27] Researcher denotes the doctoral student (i.e. author of this dissertation)

aware about a part of the RSC). The Hindi translation of questionnaire is included in Appendix 2.

Table 7: Revised structure of inquiry to understand formalization

Stages in formalization	**Propositions**	**Level 2 questions (mental line of inquiry)**	**Level 1 questions (verbal line of inquiry)**
Initial conditions			What is e-waste? Could you please give some examples?
	6b, 6c, 6d, 7d,	What was firm's condition before formalization? - Sources of e-waste - Kinds of e-waste processed - Economic value, quantity, and frequency of e-waste supply	When did the firm formalise? How did the firm function before formalization? What were the sources of e-waste? What kinds of e-waste were sourced? How much e-waste was sourced? How frequently?
	1, 7d,	What was firm's condition before formalization? - Processing operations and negative externalities - Technology used, fixed costs, variables costs, inputs and outputs	How was it processed? Technology and costs? How much was processed? What was done after processing? How health and surrounding environment was related to processing operations?
	7d, 11	How much profits did the firm make while being informal?	How was the business?
	2	Why did the firm remain informal? - Exclusion view - Exit view	How was the business run *this way*?
Catalyst of change	3	Event or development moving the firm to pursue formalization? What was the motivation for formalization? Motivation came internally or externally?	How did the firm decide to formalise?
Formalization process	5, 6a, 6b, 6c, 6d	What was the method of formalization? Competitive, Cooperative, or Integrative.	What happened in the formalization process? i.e.

		How did they decide the formalization method? Content of formalization: - Changes in processing operations - Changes in non-processing operations	could you please explain the entire formalization process?
	4	Was there any external help? How did they help?	Who were involved? How did they involve? i.e. what was their role?
	7a	Content of formalization: - Changes in processing operations: fixed costs, variable costs. - Changes in non-processing operations: costs incurred.	How much costs were incurred in formalization?
Immediate outcome	7a, 7e	What was the immediate outcome? Did profits decrease?	How was the business, immediately after formalization?
	7a, 7e	What was the immediate outcome? Improved performance of processing operations? How?	How was the change in processing operations before and after formalization?
	7a, 7e	What was the immediate outcome? Eliminating negative externalities? How?	How health and surrounding environment was related to this change?
Intermediate outcome	7b, 7c,7e	What was the intermediate outcome? - Availability of bank credit? - Business expansion? - New sources of e-waste? How much time did it take for achieving this intermediate outcome? 6 months, 1 year?	What happened after that? How did the business change?
Final outcome	7d, 7e	What was the final outcome of formalization? - New sources of e-waste? - Kinds of e-waste processed? - Economic value, quantity, and frequency of e-waste supply?	How does the firm function now? What are the sources of e-waste? What kinds of e-waste are sourced? How much e-waste is sourced? How frequently?
	7d, 7e, 8, 9, 10, 11	What was the final outcome of formalization? - What technology is used now?	How is e-waste processed now? How much does it cost to process?

		- What are the total formalization related costs: fixed and variable costs? - Where does the outputs go? - Profits? How much time did it take to achieve a stable business? 1 year, 2 years? What was the profits of formal processor in the integrative method?	How much e-waste is processed? What happens after e-waste is processed? How is the business now?
Rival explanations	12	Other new practices by firm that could affect the outcome of formalization?	Where there any changes made in the firm, apart from formalization related changes?
	12	External market conditions: Economic value, quantity of e-waste increasing every year? This could also affect the outcome of formalization.	After formalization, has there been any general trends, market trends, on quantity or kinds of e-waste every year?
	12	Influence of EMHR on outcome of formalization?	How was your experience regarding the recent e-waste legislation? i.e. was formalization affected by e-waste legislation?
Formalization challenges		To understand the formalization related challenges. This will help us while providing recommendations.	What were the challenges you faced while formalizing? How about the challenges now? i.e. after formalization?
		This is to encourage interviewees to volunteer information which interviewer may not have thought about.	Is there anything else on formalization that would be important for me to know?

Table 8: Revised structure of inquiry to understand e-waste RSC (for a respondent who is familiar with the entire RSC)

Stage in the RSC	Propositions	Level 2 questions (mental line of inquiry)	Level 1 questions (verbal line of inquiry)
Sources			What is e-waste? Could you please give some examples?
	1	-What are the different sources of e-waste? Retail consumers, bulk consumers, manufacturers, and others?	How is e-waste generated? i.e. sources of e-waste?
	2, 3, 4	-Is there a relation between type of source and type of e-waste? -What is that relation?	What kinds of e-waste are generated by these sources?
	2, 3	-Do these sources purchase differently?	How do these sources purchase them (i.e. electrical and electronic products that become e-waste)?
	6a, 6b, 6c, 6d, 7a, 7b, 8, 9	-What disposal options do they have? -How do they decide a particular disposal option? -How do retailers, manufacturers, formal processors, door-to-door collectors and scrap dealers collect e-waste from the various sources? -Is there a relation between type of e-waste and disposal option? -What is that relation?	How do these sources dispose e-waste? Are all kinds of e-waste disposed in these ways?
	5a, 5b, 5c, 5d,	-How is the economic value of products determined during disposal? -Products, information, and funds flow during disposal?	How does the transaction happen? - What materials or products are disposed? - At what prices? - How are these prices determined?
Collectors	10, 12, 16	-After purchasing e-waste from sources, to whom do the collectors sell? -Why do they sell?	What happens next? How does that happen?
	10, 12	-How is the economic value of products determined in this transaction? -Products, information, and funds flow during this transaction?	How does the transaction happen? - What materials or products are disposed? - At what prices? - How are these prices determined?
Processors	11, 12, 16	-How does formal processors and informal processors purchase e-waste from collectors? i.e. to whom does collectors sell e-waste? -Why do they sell? -Retailers, dealers, manufacturers, informal processors, formal processors, scrap dealers, door-to-	What happens next? How does that happen?

		door collectors are individual profit-maximizing stakeholders? -Is there any interaction between formal and informal processors? Why?	
	11, 12	-How is the economic value of products determined in this transaction? -Products, information, and funds flow during this transaction?	How does the transaction happen? - What materials or products are disposed? - At what prices? - How are these prices determined?
Processing operations	13a, 13h	-The five e-waste processing operations -Are there other processing operations? What are they?	How is e-waste processed?
	14a, 14b	-Are all processing operations done by a single processor? Or is there specialization in processing operations?	Who does these processing operations? Do all processors do these operations?
	13b, 13c, 13d, 13e, 13f, 13g	-How do the processors choose a particular processing operation for a product? Based on functionality, modularity, and demand in second hand-market?	How a particular processing operation is decided?
	14c	-Formal processors: The specific technology used, fixed costs, variable costs, inputs and outputs? -Informal processors: The specific technology used, fixed costs, variable costs, inputs and outputs? -Difference in the quality of outputs between formal and informal processors?	How about the typical processing costs incurred? Do all processors incur the same costs? Do all processors produce the same kind of output?
	15	-Which processing operations of informal processors create negative externalities? Why? -Do processing operations of formal processors create negative externalities? Why?	How is health and surrounding environment related to processing operations?
Final destinations	13h, 13b, 13f, 13g, 16	-How e-waste parts/materials reach secondary smelters, second-hand markets, manufacturers, metal markets, and landfill after processing?	What happens next? How does that happen?
	13b, 13f, 13g	-How is the economic value of products/materials determined in this transaction? -Products, information, and funds flow during this transaction?	How does the transaction happen? - What materials or products are disposed? - At what prices? - How are these prices determined?

	17	-Are these materials used in the manufacture of same products to same set of consumers (i.e. sources of e-waste)?	What do they do with it?
Emergent questions		Is the recycling/processing value decreasing over the years, increasing over the years, or neutral? Why?	Based on your experience over these many years, how has been the recycling/processing value from e-waste?
	13b, 13c, 13d, 13e, 13f, 13g	Are all products/brands easy to process? Any products/brands that are difficult to process? Why? Is it due to design modularity i.e. modular products are easy to process when compared to integral products.	Based on your experience over these many years, what do you think of the relation between recycling/processing value and manufacturer's brand? i.e. some brand or products are easy to process, some brands or products not easy…from some brands, parts can be easily taken out…some brands fetch more money in the market, etc. Why?
		Weight of products decreasing? High value material substituted with low value materials? (ex: aluminium or steel substituted with plastic, etc.) Product design becoming more integral/modular?	Based on your experience over these many years, how has been the product design aspect evolving? i.e. changes in design, materials used, components, etc. Why?
General	17	-Are the activities in the RSC decentralized? Why? - Is the RSC described same throughout India?	Are there any activities, processing operations that occur only in a particular city or region? How does that happen?
	18	-How did EMHR impact e-waste RSC? -New links created? Old links destroyed?	How was your experience regarding the recent e-waste legislation?
		This is to encourage interviewees to volunteer information which interviewer may not have thought about.	Is there anything else on e-waste that would be important for me to know?

Table 9: Revised structure of inquiry, for individual stakeholders, to understand e-waste RSC

Stage in the RSC	Propositions	Level 2 questions (mental line of inquiry)	Level 1 questions (verbal line of inquiry)
Sources			What is e-waste? Could you please give some examples?
	1	-What are the different sources of e-waste? Retail consumers, bulk consumers, manufacturers, and others?	
	2, 3, 4	-Is there a relation between type of source and type of e-waste? -What is that relation?	What kinds of e-waste does the organization generate?
	2, 3	-Do these sources purchase differently?	How does the organization purchase these electrical and electronic products, that becomes e-waste?
	6a, 6b, 6c, 6d, 7a, 7b 8, 9	-What disposal options do they have? -How do they decide a particular disposal option? -How do retailers, manufacturers, formal processors, door-to-door collectors and scrap dealers collect e-waste from the various sources? -Is there a relation between type of e-waste and disposal option? -What is that relation?	How does the organization dispose the e-waste generated? Are all kinds of e-waste disposed in these ways?
	5a, 5b, 5c, 5d,	-How is the economic value of products determined during disposal? -Products, information, and funds flow during disposal?	How does the transaction happen? - What materials or products are disposed? - At what prices? - How are these prices determined?
Collectors	10, 12, 16	-After purchasing e-waste from sources, to whom do the collectors sell? -Why do they sell?	What is e-waste? Could you please give some examples? How does your organisation collect e-waste / electrical and electronic products discarded by consumers? What kinds of e-waste (products) are collected?
	10, 11, 12, 16	-How is the economic value of products determined in this transaction? -Products, information, and funds flow during this transaction? -How does formal processors and informal processors purchase e-waste from collectors? i.e. to whom does collectors sell e-waste?	How does the transaction happen? - What materials or products are collected? - At what prices? - How are these prices determined?

		-Why do they sell? -Retailers, dealers, manufacturers, informal processors, formal processors, scrap dealers, door-to-door collectors are individual profit-maximising stakeholders? -Is there any interaction between formal and informal processors? Why? -How is the economic value of products determined in this transaction? -Products, information, and funds flow during this transaction?	What happens to these products after collection? How does that happen? How does the transaction happen? - What materials or products? - At what prices? - How are these prices determined?
	This makes more sense for manufacturers	Weight of products decreasing? High value material substituted with low value materials? (ex: aluminium or steel substituted with plastic, etc.) Product design becoming more integral/modular?	Based on your experience over these many years, how has been the product design aspect evolving? i.e. changes in design, materials used, components, etc. Why?
	13b, 13c, 13d, 13e, 13f, 13g	Are all products/brands easy to process? Any products/brands that are difficult to process? Why? Is it due to design modularity i.e. modular products are easy to process when compared to integral products.	Based on your experience over these many years, what do you think of the relation between recycling/processing value and manufacturer's brand? i.e. some brand or products are easy to process, some brands or products not easy…from some brands, parts can be easily taken out…some brands fetch more money in the market, etc. Why?
		Is the recycling/processing value decreasing over the years, increasing over the years, or neutral? Why?	Based on your experience over these many years, how has been the recycling/processing value from e-waste?
	11, 12, 16	-How does formal processors and informal processors purchase e-waste from collectors? i.e. to whom does collectors sell e-waste? -Why do they sell? -Retailers, dealers, manufacturers, informal processors, formal processors, scrap dealers, door-to-door collectors are individual profit-maximizing stakeholders? -Is there any interaction between formal and informal processors? Why?	What is e-waste? Could you please give some examples? How does your organisation collect e-waste / electrical and electronic products discarded by consumers? What kinds of e-waste (products) are collected?
	11, 12	-How is the economic value of products determined in this transaction?	How does the transaction happen?

		-Products, information, and funds flow during this transaction?	- What materials or products are collected? - At what prices? - How are these prices determined?
Processors	13a, 13h	-The five e-waste processing operations -Are there other processing operations? What are they?	How is e-waste processed by the organisation?
	14a, 14b	-Are all processing operations done by a single processor? Or is there specialization in processing operations?	
	13b, 13c, 13d, 13e, 13f, 13g	-How do the processors choose a particular processing operation for a product? Based on functionality, modularity, and demand in second hand-market?	How a particular processing operation is decided?
	14c	-Formal processors: The specific technology used, fixed costs, variable costs, inputs and outputs? -Informal processors: The specific technology used, fixed costs, variable costs, inputs and outputs? -Difference in the quality of outputs between formal and informal processors?	How about the typical processing costs incurred? What kind of output is produced?
	15	-Which processing operations of informal processors create negative externalities? Why? -Do processing operations of formal processors create negative externalities? Why?	How is health and surrounding environment related to processing operations?
	13h, 13b, 13f, 13g, 16	-How e-waste parts/materials reach secondary smelters, second-hand markets, manufacturers, metal markets, and landfill after processing?	What happens next, after e-waste is processed? How does that happen?
	13b, 13f, 13g	-How is the economic value of products/materials determined in this transaction? -Products, information, and funds flow during this transaction?	How does the transaction happen? - What materials or products? - At what prices? - How are these prices determined?
	17	-Are these materials used in the manufacture of same products to same set of consumers (i.e. sources of e-waste)?	What do they do with it?
		Is the recycling/processing value decreasing over the years, increasing over the years, or neutral? Why?	Based on your experience over these many years, how has been the recycling/processing value from e-waste?
	13b, 13c, 13d, 13e, 13f, 13g	Are all products/brands easy to process? Any products/brands that are difficult to process?	Based on your experience over these many years, what do you think of the relation between

		Why? Is it due to design modularity i.e. modular products are easy to process when compared to integral products.	recycling/processing value and manufacturer's brand? i.e. some brand or products are easy to process, some brands or products not easy…from some brands, parts can be easily taken out…some brands fetch more money in the market, etc. Why?
		Weight of products decreasing? High value material substituted with low value materials? (ex: aluminium or steel substituted with plastic, etc.) Product design becoming more integral/modular?	Based on your experience over these many years, how has been the product design aspect evolving? i.e. changes in design, materials used, components, etc. Why?
Final destinations	13h, 13b, 13f, 13g, 16	-How e-waste parts/materials reach secondary smelters, second-hand markets, manufacturers, metal markets, and landfill after processing?	How does your organisation collect raw materials / inputs?
	13b, 13f, 13g	-How is the economic value of products/materials determined in this transaction? -Products, information, and funds flow during this transaction?	How does the transaction happen? - What materials or products are collected? - At what prices? - How are these prices determined?
	17	-Are these materials used in the manufacture of same products to same set of consumers (i.e. sources of e-waste)?	What happens next, after collecting raw material?
General	17	-Are the activities in the RSC decentralized? Why? - Is the RSC described same throughout India?	Are there any activities, processing operations that occur only in a particular city or region? How does that happen?
	18	-How did EMHR impact e-waste RSC? -New links created? Old links destroyed?	How was your experience regarding the recent e-waste legislation?
		This is to encourage interviewees to volunteer information which interviewer may not have thought about.	Is there anything else on e-waste that would be important for me to know?

Other modifications in this revised structure of inquiry are as follows. Level 1 questions in the processors stage include: "What happens next? How?" This is because, we hypothesized that there would be more intermediaries from collectors to processors other than what we had conceptualized. This question helps to understand those intermediaries, if any. Level 1

questions are fluid than rigid, as the focus is on guided conversations. It is to be emphasized that actual conversational questions to enthusiastic interviewees may include normative questions on e-waste management that go beyond the scope of our study, like: "In your opinion, what is a good system/model for managing e-waste?" Such questions also enable the interviewees to perceive themselves as 'masters' and the interviewee as 'novice'. This helps in achieving greater participation. We have used "How" instead of "Why" in the Level 1 questions because "why" question creates defensiveness on the informant. The "how" question can address the "why" question in an actual conversation (Yin, 2009). While revising the initial structure of inquiry, we also included probes that can be used during the interview. Probes are used to ask follow-up questions, when the researcher does not understand the response or the response is vague/ambiguous (Stewart & Cash, 2010). These probes are summarized in Table 10 (adapted from Stewart & Cash, 2010), below.

Table 10: List of probes used for interview

Types of questions	Explanation	When to use
Silent probes	Remain silent and use appropriate non-verbal signals to encourage the interviewee to continue.	When the answer is incomplete or interviewee is hesitant to continue.
Nudging probes	A simple word or a phrase nudging the interviewee to continue. For example, I see, ok, uh-huh, etc.	When a silent probe fails.
Clearinghouse probes	Multiple worded sentence to encourage interviewees to volunteer information which interviewer may not have thought about. For example, Is there anything else that would be important for me to know?	To find if a series of questions has uncovered every important point on the topic.
Informational probes	Multiple worded sentence to get additional information. For example, can you tell me more about it? , what do you mean by that? , etc.	If an answer appears to be superficial and not meeting our research objective.
Restatement probes	Restating part of the primary question or rephrasing the primary question.	When interviewee does not answer the question or partially answers.
Reflective probes	Multiple worded sentence, reflecting the answer just received to verify or clarify. For example, by ABC, did you mean XYZ?	When the answer is inaccurate or interviewer is unsure of what interviewee had said or implied.
Mirror probes	Multiple worded sentence, mirroring (i.e. summarizing) a series of answers to ensure accurate understanding.	When the interviewer needs to be certain of what the interviewee had said.

Some questions were kept as a last resort, just in case we come across an unexpected stakeholder in the e-waste RSC. These questions are: "What are your inputs i.e. kinds of e-waste? Who supplies it? How does the transaction happen? What do you do with these inputs? What are your outputs? Who are the buyers for your outputs? How does the transaction

happen?” Such kind of questions were also asked to stakeholders who cannot relate their business directly with that of e-waste (for example, a plastic smelter would say that his inputs are derived from many sources and e-waste is just one of them). This revised structure of inquiry was also matched with the principles (principles to motivate respondents, formulate questions, and probing) outlined in the classic book on interviewing by Kahn & Cannell (1957). We also presented the principles of this book to the doctoral student colleagues in the institute. This helped to match the principles outlined in the book with our research design.

3B.3 Data collection from primary sources

Data collection began on 20th March 2014 and ended on 11th July 2016. The details of data collection regarding date, organization, name of the respondent, designation of the respondent, coordinates of the respondent, method of data collection (interview/direct observation/informal conversation), whether recorded or not, duration, location, and time are stored in an Excel file and can be shared upon request.

Formalization study: There are totally 10 informal-turned-formal firms[28] in Bangalore. The formalization of informal processors was initiated by the intervention of STIMULUS (this is a disguised name). STIMULUS is a collaborative project funded by European Union and involved stakeholders from the industry, environmental ministry of India, and research organizations from Switzerland. There is also one firm each in Delhi and Kolkata that have become formal through the intervention of STIMULUS. But, it is only in Bangalore the informal-turned-formal firms are active and does full-fledged e-waste processing. STIMULUS started the initiative in Bangalore, to formalize the informal e-waste processors, from the year 2003. This initiative has recently spread to other cities like Delhi and Kolkata. Thus, informal-turned-formal firms in Bangalore offer a rich setting to study this formalization phenomenon which has existed for a longer time duration. Wherever possible, evidence regarding formalization of firms in Delhi and Kolkata has been obtained through publicly available secondary sources. Bangalore is the 3rd largest generator of e-waste in India, generating 92,000 MT e-waste every year (Assocham - Frost & Sullivan, 2016). Using conservative estimates and

[28] The two terms “informal-turned-formal firms” and “informal-turned-formal processors” are used synonymously.

back-of-the-envelope calculations, the e-waste processing market in Bangalore is expected to be higher than $20 million[29].

We attempted to include all the 10 informal-turned-formal firms in the sample i.e. a complete census. All the 10 firms were approached through telephonic calls and in-person, during stakeholders' meetings, for conducting this study. Only 6 firms gave access after persistent attempts. Even the firms (for example, Alpha) that were friendly during the pilot study in 2011, turned hostile and was not permitting any students or research scholars for academic project works. After repeated requests and participation in stakeholders' meetings, six firms realized the seriousness of this study and gave permission to be interviewed. Informal conversations happened with few other firms, who did not wish to be interviewed, during recess in stakeholders' meetings. A brief summary of the informal-turned-formal firms (with disguised names) included in the study can be found in Table 11 and Table 12.

Table 11: Informal-turned-formal firms included in the sample

Name of the firm	Year at which formalization began	Year at which the firm became formal	Persons interviewed
Alpha	2005	2009	Proprietor
Beta	2006	2010	Management Head
Gamma	2008	2012	Joint Proprietors
Delta	2010	2012	Proprietor
Epsilon	2010	2012	Business Development Manager
Zeta	2013	2014	Proprietor

Table 12: Characteristics of informal-turned-formal firms included in the sample

Name of the firm	Size (no. of employees)	Size of facility* (sq. ft.)	Capacity (MT per annum)	E-waste processing operation
Alpha	9	990	300	Disassembly
Beta	9	780	300	Disassembly & metal recovery
Gamma	6	2500	730	Disassembly
Delta	8	1200	780	Disassembly & metal recovery
Epsilon	10	4446	1250	Disassembly & metal recovery
Zeta**	15	2400	360	Disassembly

*This only denotes the built-up area
**At the time of fieldwork, Zeta was in the process of applying for metal recovery license
MT denotes Metric Tonne. I MT = 1000 kg

Disassembly means dismantling e-waste and segregating into commodities like ferrous metals, non-ferrous metals, plastic, and glass. Metal recovery means extraction of precious metals like

[29] According to CPCB report, India generated more than 8 lakh MT e-waste in 2012. Frost & Sullivan estimated e-waste processing market to be worth $1,900 million in 2012. A simple division multiplied by the quantity of e-waste generated in Bangalore every year, revealed a market worth $218,50,000.

gold, silver, copper, palladium, platinum from printed circuit boards. It is not be noted that all these firms also does other processing operations like direct reuse, repair, and cannibalization. These processing operations are described in detail in Chapter 5. Alpha was the first firm to become formal and Zeta was the most recent firm to become formal. After Zeta got formalized, no other firms have been authorized by the Government (at the time of fieldwork). Though, Epsilon's Business Development Manager was interviewed, no evidence could be obtained regarding their formalization process. This is because the Business Development Manager joined Epsilon after it became formal. However, evidence regarding formalization after Epsilon became formal, was gathered. The Proprietor of Epsilon, who would have knowledge about the formalization process, was not willing to be interviewed in-spite of repeated requests over phone and in-person. One reason why many firms (including Epsilon) declining our requests is due to 'respondent fatigue'. These informal-turned-formal firms were visibly fed-up with students and journalists. There have been cases where journalists posed as students entered their facilities, and leaked out photos and other information in newspapers. Hence, our presence was initially viewed with suspicion. This problem was resolved only after a rapport was established by participation in stakeholders' meetings and referrals by known people (i.e. people who were credible in the eyes of these informal-turned-formal firms).

Apart from these informal-turned-formal firms, following stakeholders were also interviewed to understand formalization:

- Two Consultants from STIMULUS who initiated the formalization process in Bangalore and helped the firms become formal. These Consultants have knowledge about all the informal-turned-formal firms in Bangalore due to their deep immersion in the field from 2003 onwards.
- Three officials from a Governmental organization who are responsible for authorizing the informal firms and enforcing, monitoring EMHR.

Evidence gathered from other stakeholders in the e-waste reverse supply chain are also included in this study of formalization, wherever appropriate.

All the 10 informal-turned-formal firms are small firms run privately based on sole proprietorship or partnership. The six firms included in the sample differ across age (i.e. time period of formalization), processing operations (i.e. three firms majorly does disassembly, three firms majorly does disassembly & metal recovery), size of facility (780 sq. ft. to 4446 sq. ft.),

and capacity (300 MT to 1250 MT). Our sample includes the first two firms to get formalized (i.e. Alpha and Beta) and the last firm to get formalized (i.e. Zeta). This time dimension would also help to understand the whether the patterns of formalization process persist over a period of time. Hence, the firms in our sample differ on a range of measures like age, processing operations, size of facility, and capacity.

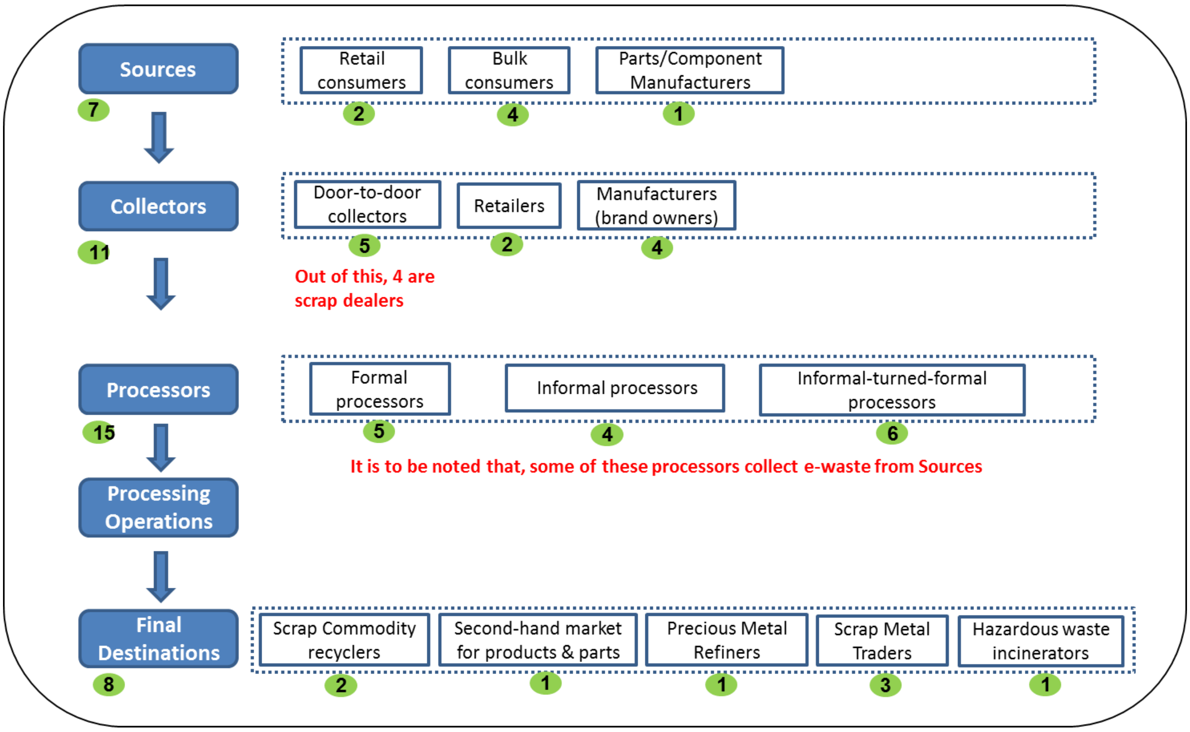
Structure of e-waste RSC: Evidence from informal-turned-formal processors, being a part of the e-waste RSC, are also useful to understand the structure of RSC. For example, the processing operations of informal-turned-formal processors, how they purchase e-waste, how they dispose e-waste, etc. are also used to build an understanding of the RSC structure. Apart from this, other stakeholders in the RSC were interviewed. Totally, 49 stakeholders in the e-waste RSC were interviewed. This included 44 face-to-face interviews and 5 telephonic interviews. Audio of interviews with 42 stakeholders were recorded with permission. A summary of stakeholders interviewed are available in Table 13. A detailed list of the stakeholders interviewed are available in Appendix 3.

Table 13: Summary of stakeholders interviewed

Stage of RSC	**Types of stakeholders**	**Total number of stakeholders**
Sources	Retail Consumers, Bulk Consumers, Parts/Component manufacturers	7
Collectors	Door-to-door Collectors (some of them are also Scrap Dealers/Traders), Retailers, Manufacturers (brand owners).	11
Processors	Formal Processors, Informal Processors, Informal-turned-formal Processors	15
Final Destinations	Scrap commodity recyclers, Precious metal refiners, Scrap metal traders, Hazardous waste incinerators	8
Other stakeholders	A manufacturer of e-waste processing machinery, 4 NGOs, and 3 Government officers	8

This is also illustrated in Figure 10 below.

Figure 10: Stakeholders interviewed across the e-waste RSC



Apart from interviews, we held informal conversations (not structured interviews) with numerous stakeholders (they are not included in the above figure) to understand their perspectives[30]. For example, we had more than an hour of informal conversation with a recycling enthusiast who had two decades experience in the auto industry. Similarly, we had informal conversation with the Chief Manager of a large Formal Processor, while waiting for hours, at a Government organization. Such respondents were not willing to be interviewed, but were willing to talk generally. We have also done direct observation of 12 events pertaining to e-waste. These events are as follows:

- E-waste stakeholders' meeting at a Government organization
- Meeting of informal and informal-turned-formal e-waste processors organized by STIMULUS
- Trash trail of municipal waste (organized by NGO)
- Industry Conference of Printed Circuit Board Manufacturers
- Panel discussion on E-waste Recycling; E-waste Recycling Photo, Video Exhibition
- Industry Conference of Electronics Manufacturers
- E-waste Collection Drive for 3 days, by engaging with an e-waste collector

[30] These details are recorded in an Excel file, and can be shared upon request.

- E-waste Processors' (Informal & Formal) meeting at a Government organization
- Processing operations of an Informal Processor
- Part of a meeting between Door-to-door e-waste Collector and Formal Processor
- Part of a meeting between Machinery manufacturer and Formal Processors
- Industry Conference of scrap metal recyclers and scrap metal importers

In total, data from primary sources constituted 9,630 minutes (160 hours). We collected evidence from rather unusual sites like Printed Circuit Board Manufacturers' conference, Trash Trail of municipal waste (this is a city tour where the organizer took us through the reverse supply chain of municipal waste, by physically visiting each stage of the chain), Electronics Manufacturers' conference, Metal Recyclers' Conference. The rationale behind this is as follows. Take the case of a computer manufactured by a firm. The various components in the computer, like PCB, is not manufactured by this firm. These components are manufactured by another set of firms and this firm assembles them to make its final product i.e. computer. During the fieldwork, we realized that these components are also e-waste. For example, the defective PCBs are sold to scrap dealers or informal processors by the PCB manufacturing firms. The processors whom we interviewed spoke about PCBs because: (a) it is present in every electronic product including large telecom servers (b) e-waste processors get maximum economic value from PCBs (c) some processors were saying that recovery value of PCBs have been reducing over the years (d) evolution of product designs and reducing value of materials inside products. This led us to investigate what is happening in components manufacturing industry and PCB manufacturing industry, though this was not the focus when we started the research study. Similarly, during the fieldwork it was realized that e-waste products also flow through the municipal waste RSC and one also needed to understand what happens in that chain. Further, during the fieldwork we also realized that ultimately every metal in e-waste products ends up with scrap metal traders and scrap metal recyclers. This led us to understand the scrap metal recycling industry. The purpose behind doing all this was to understand this e-waste processing industry in its totality.

Deciding the appropriate sample size

Before getting into sample size determination, let us recap our objective. Our objective is to develop an understanding of the e-waste RSC, formalization. We do not narrowly focus on a

particular part of the RSC, formalization. Our objective is to get the *big picture*. This *big picture* (though difficult to obtain) has a value in itself. Now, the question is how can you get this big picture in a rigorous way? This big picture that is obtained using a rigorous way can be used to develop an understanding of RSC, formalization. How should we sample in order to get the *big picture?* Determination of sample size is done based on several trade-offs involved i.e. willingness of the firm to participate, time and funding issues, the information that can be obtained (Miles & Huberman, 1994; Patton, 2002). Though there are several strategies proposed, the aims of the research study should guide how to select the sample and deciding the sample size (Yin, 2009). We need stakeholders who are spread across the RSC – stakeholders who can give rich information on various parts of the RSC (i.e. we need a set of diverse stakeholders, we need to sample for heterogeneity or maximum variation). Firstly, the stakeholders should have willingness to participate in our study. If we have interviewed one stakeholder, we need to move to another stakeholder (ideally) to get the *big picture*. Even if we interview one stakeholder, the specific issues covered will be common across similar stakeholders. For example, if we interview one Bulk Consumer, the specifics of the discussion (based on the role in RSC) would be applicable to other Bulk Consumers with some variations. Our objective is not to understand the specifics of all Bulk Consumers. Rather, we intend to study the role of this stakeholder in the entire RSC. Some stakeholders would have intimate knowledge of other stakeholders. For example, e-waste processors have an intimate knowledge of how Bulk Consumers dispose e-waste; e-waste processors also have intimate knowledge of where does e-waste go after it is processed i.e. stakeholders have deeper understanding of immediate upstream and downstream links in the supply chain. This understanding can be used to get the *big picture.* So, interviewing 1 stakeholder each (in the supply chain) is sufficient for a study of this nature – i.e. to get the *big picture*. The findings from this study can be used to develop rich propositions that can be tested in the field using a well-funded large sample study.

Patton (2002) reports 16 types of sampling for qualitative research. Given our objective, we need to use <u>maximum variation sampling</u> method i.e. *the researcher selects a small number of units or cases purposively that maximizes the diversity relevant to the research question.* Such a sampling method suits exploratory nature of our research questions. The objective is to capture and describe RSC/formalization that cut across a heterogeneous group of respondents, to achieve maximum variation within stages. Patton (2002) described this technique of maximum variation sampling in the context of evaluating the effectiveness of public policy programs:

> "This strategy for purposeful sampling aims at capturing and describing the central themes or principal outcomes that cut across a great deal of participant or program variation. For small samples a great deal of heterogeneity can be a problem because individual cases are so different from each other. The maximum variation sampling strategy turns that apparent weakness into a strength by applying the following logic: Any common patterns that emerge from great variation are of particular interest and value in capturing the core experiences and central, shared aspects or impacts of a program."

From the evidence collected so far, there is maximum variation within stages i.e. we have heterogeneous group of respondents within a stage. For example, take the stage Sources: we have interviewed 7 stakeholders including 2 Retail Consumers, 4 Bulk Consumers (1 Government organization, 3 private organizations), and 1 Products/Components Manufacturer. The manner in which they dispose e-waste and to whom it goes are very different i.e. there is maximum variation. But, there is a common thread (RSC) that cuts across them. Similarly, there is variation in among stages Collectors, Processors, Final destinations, and Other Stakeholders. Our focus has been to obtain maximum within-stage variation, not within-stakeholder variation i.e. instead of looking for variation within each stakeholder, we were looking for variation within each stage of the e-waste RSC.

This maximum variation sampling approach has also been used for the study on formalization process: we have interviewed the first informal-turned-formal processor, the most recently formalized processor, and 3 processors who were formalized between the first and last. Out of these, 3 processors does majorly disassembly and 2 processors do disassembly and metal recovery. We have also interviewed 2 consultants who helped the processors formalize and Government officials who authorize (give license) these informal processors. Therefore, there is maximum variation in our sample for the formalization study. Apart from this, stakeholders from others parts of RSC who had something to say about formalization are also considered while analyzing the evidence for formalization study.

Maximum variation sampling in OM literature

This technique of maximum variation sampling has also been used by OM scholars for studying supply chains. For example, Ketchen et al. (2014) had used this sampling method for studying the issue of product recalls in the supply chain. They said: "Selecting firms along the supply chain that varied in size and scope allowed us to develop a rich understanding of how recalls unfold across a wide range of products". We also referred OM literature that does qualitative studies of multi-tier supply chains. Mena et al. (2013) studied a three tier chain: Buyer => Supplier => Supplier's Supplier. 8 companies were approached and 3 companies agreed to participate. These companies helped researchers to get to other companies in their network. A summary of their data collection is available in Table 14, below. This table is adopted from their paper.

Table 14: Data collection from multi-tier supply chain (Mena et al., 2013)

	Buyer	Supplier	Supplier's Supplier
Case 1: Beer	Multinational brewing company	Grain trader	Farmers association
Case 2: Bread	U.K.-based baker	Miller 1	Marketing cooperative
Case 3: Pork	U.K.-based retailer	Pork processor	Pork breeder

Total interviews done: Case 1 = 9; Case 2 = 8; Case 3 = 11. It is not specified in this paper regarding how many interviews are done within each stakeholder in the chain. Bhakoo & Choi (2013) studied a three tier chain: Manufacturer => Distributor => Hospital chain for pharma products. The authors said: "After a series of communications, three manufacturers, two distributors and five hospitals agreed to participate in this study. Of the five hospitals that participated in this study, three were based in metropolitan Melbourne and were of larger size. The other two were smaller hospitals, one of which specialized in eye and ear ailments and the other serviced a regional community. Among the manufacturers, two were of a similar size with headquarters in the USA, and one was based in Australia. As there are only a handful of distributors operating in the Australian market, we chose the two most prominent distributors. One dealt only with hospitals and the other supplied to hospitals as well as retail pharmacies." Apart from stakeholders in this chain the authors also conducted interviews with experts in the healthcare industry. Wu & Choi (2005) studied a three-tier chain by focusing on Buyer => Supplier => Supplier's Supplier. 18 companies (buyers) with leading purchasing practices were selected by referring prominent business magazines; 8 companies were finally decided based on the type of product purchased by the company; the idea was to fill the 4 quadrants of a well-

known purchasing matrix (conceptual framework) and 2 companies were filled in each quadrant. Interviews done by the authors are described in Table 15, below. This table is adopted from their work.

Table 15: Data collection from multi-tier supply chain (Wu & Choi, 2005)

Buyer	Number of suppliers considered	Number of interviews with buyer	Number of interviews with suppliers
Case 1	2	6	0
Case 2	2	4	0
Case 3	14	9	7
Case 4	2	6	2
Case 5	9	3	1
Case 6	2	3	3
Case 7	2	3	1
Case 8	2	5	1

Wu & Choi (2005) justified their sampling, as follows: "Eisenhardt (1989) recommended about seven cases as being ideal for theory-building purposes, if less, the study might suffer from lack of generalizability, but if too many, the researchers would not be able to process the qualitative data." Choi & Hong (2002) studied the supply network of two firms: Honda and Daimler who are known for their supplier management. Three varied product lines are: family car (Honda Accord), luxury car (Acura CL/TL), and jeep/truck (DaimlerChrysler Grand Cherokee). Focus of this study was on a particular assembly i.e. the center console assembly. The chain that was finally studied was this: 2 final assemblers (Honda & Daimler) => 3 top-tier suppliers => 3 second-tier suppliers. Since it was not possible for the authors to visit all companies in the supply networks, the data obtained from top-tier suppliers regarding the structure of the supply networks were given more weight. Both in Honda and Daimler, all buyers and the purchasing managers involved in the purchasing of the center console for the given product line were interviewed. Conducting interviews with suppliers, a minimum of three individuals: the sales representative that interfaces the customer, the operations or materials manager that is responsible for delivering the center console to the customer, and the buyer that procures parts and materials for the product that goes into the center console. The intent was to collect data on the upstream and downstream supply-network structure. The following Table 16 (adopted from their study) summarizes the data collection done.

Table 16: Data collection from multi-tier supply chain (Choi & Hong, 2002)

Companies	Product associated with center console	Number of informants
Final assemblers		
Honda of America	Honda Accord	4
	Acura CL/TL	4
DaimlerChrysler	Grand Cherokee	6
Top-tier suppliers		
CVTa	Console assembly	7
Inteka	Console assembly	5
Textron Trim	Console assembly	5
Select second-tier suppliers		
Emhart	Clip	3
JFCa	Cup holder	3
Leon	Front console mat	2

These OM papers, discussed above, did not write about a strong theoretical/logical rationale for closing data collection from primary sources. Rather, these papers only discused how they sampled and how the sample was relevant to the research question studied.

A flexible research and sampling design is an important feature of qualitative research, particularly when the research being conducted is exploratory in nature (Miles & Huberman, 1994; Patton, 2002). This is also consistent with the observation made by Patton (2002):

> "Sampling to the point of redundancy is an ideal, one that works best for basic research, unlimited time lines, and unconstrained resources…There are no rules for sample size in qualitative inquiry. Sample size depends on what you want to know, the purpose of the inquiry, what's at stake, what will be useful, what will have credibility, and what can be done with available time and resources… In the end, sample size adequacy, like all aspects of research, is subject to peer review, consensual validation, and judgment. What is crucial is that the sampling procedures and decisions be fully described, explained, and justified so that information users and peer reviewers have the appropriate context for judging the sample. The researcher or evaluator is absolutely obligated to discuss how the sample affected the findings, the strengths and weaknesses of the sampling procedures, and any other design decisions that are relevant for interpreting and understanding the reported results."

How did we *actually* reach the respondents? Snowball method was particularly helpful. Consultants X and Y from STIMULUS were particularly helpful by providing the phone numbers of all informal-turned-formal processors. Later, while calling them to request for meeting, we gave the reference of these consultants. Also, participating in stakeholders' meetings helped us to know about other potential respondents and requested for a meeting by talking to them over tea-breaks. For example, we met Product Take-back Manager of LED, Informal Processor A, Business Development Manager of Epsilon, etc. during such industry events/stakeholders' meetings. Some stakeholders gave us the contact of some other stakeholders and asked us to use their reference. For example, Zonal Manager of AMO gave us the contact of the Proprietor of COOL who collects e-waste from AMO; Manager of the IT Department at MIB gave the contact of Business Development Manager of CIT who buys e-waste from MIB; a Bank Manager who we met during an industry event gave me the contact of HR and Purchase executives at LDF; Product Take-back Manager of LED gave the contact of the Sustainability Head at AIK.

Transcribing data from recorded interviews and preparing memos

Data from primary sources (interviews with stakeholders; direct observation and informal conversation with stakeholders during meetings, etc.) were transcribed as soon as possible. There are two types here: memos and direct transcript of what the respondent said. Memos of interviews, direct observation and informal conversation were made the same day itself. The following protocol was used for writing memos. As soon as the data collection from primary source got over, we got out of the respondent's location, took out the audio recorder and *shouted* regarding what was the new thing that emerged from this primary source, anything interesting, etc. Then, we came to the laptop, played this audio, and started typing. In the process, certain new ideas would also come and those were documented. For interviews where permission to record the audio was not granted, notes were taken in the field notebook during the interview. After the interview is over and the researcher came out of the respondent's location, the researcher *shouted* (i.e. spoke freely without adhering to grammatical correctness) to the audio recorder whatever the respondent said. This was used to prepare detailed notes, when permission to record was not granted. These methods evolved during the field study, when we realized that taking down notes while the respondent was talking disrupts the smooth flow of the interview. Also, the very act of writing down notes during the interview sometimes

feared the respondents. They kept checking what we have written down in the notebook. This often disrupted the flow of the interview.

Preparing memos after each interview helped to achieve some overlap between data analysis and data collection (Yin, 2009). The memos were running commentaries about our impressions, thoughts, and emergent ideas. If a new line of thinking or themes emerge during these initial analyses, we altered the data collection plan by adding new experts for interview, modifying interview questions, or add a different source of data if such modifications are likely to provide new insights into the phenomenon (Yin, 2009). This is how new stakeholders like PCB manufacturers, scrap metal supply chain stakeholders, etc. were interviewed.

Verbatim transcription of interviews could not be done within 24 hours after the interview is over (though the researcher had tried doing it). A one-hour interview took 7-8 hours for transcribing. Data collection from primary sources were happening in lumps. There were lean periods (no interview for weeks) and there were busy periods (there would be one interview every day continuously for 3 days). On a typical day of a busy period, we would travel for 2 hours and reach the respondent's location during afternoon. After completing the interview, we would again travel for 2 hours and come back to our location in the late evening. By that time, we would have captured the memos of this interview. But, it was too tiring to start verbatim transcription in the night, because we would have to go to another respondent the very next day during busy periods. So, verbatim transcription was done as and when we got time to relax, during lean periods. While doing verbatim transcription of interviews, emerging lines of thought were documented in the memos. This verbatim transcription was done using the assistance of a software tool oTranscribe (this tool only eases the process of transcribing).

All Informal Processors and Informal-turned-formal Processors spoke in Hindi. This was translated into English while doing verbatim transcription of interviews and transcribing direct observation & informal conversation. Some words and sentences that are translated do not convey the literal meaning. For example, one respondent said in Hindi: "*we are doing business for eating"* (this is literal translation). 'Eating' should not be construed in the literal sense, rather 'eating' should be understood in the survival (livelihood) sense. We have tried to retain the literal translation wherever possible and included the actual intended meaning inside square brackets. During these interviews, there were some instances where the respondent spoke English sentences or words. They are retained as it is, in the transcript. Verbatim transcripts of

all recorded interviews and summary of un-recorded interviews were e-mailed to the respective respondents and their feedback was solicited. Three respondents gave their feedback and some minor changes to be made in the transcript. To all the respondents who spoke Hindi, the English transcript of interviews were sent.

During the data collection from primary sources (interviews, direct observation & informal conversation), the researcher had maintained a field notebook to take down notes and other details. The notes made were further expanded while preparing detailed memos and interview transcripts. This notebook can also be made available upon request.

3B.4 Data collection from secondary sources

Secondary data (evidence) refers to information gathered by someone other than the researcher to serve his or her specific purpose and not created for our research. Evidence from secondary sources is required for our study to corroborate and augment evidence obtained from primary sources. The exact details of events, names, and references contained in secondary evidence were given importance because they are grounded evidence and the inferences were treated as leads for further search (Yin, 2009).

There are two types of data obtained from secondary sources: (1) Documents (private) obtained from respondents (2) References (i.e. publicly available secondary sources). A copy of documents were also obtained privately from stakeholders. For example, a copy of the Detailed Project Reports (DPRs) submitted by Alpha, Beta, Gamma, Delta, Epsilon were obtained from Consultant X; a copy of project work done on Jamnagar Brass scrap industry was obtained from Founder and Director of MMT; a copy of master’s thesis on informal e-waste processors was obtained from Consultant X; details regarding what e-waste was sold at what price to which scrap dealer was obtained from Managers of the IT Department and Electrical Department at MIB; etc.

Evidence from secondary sources (i.e. references) were collected systematically using news databases like Factiva, LexisNexis, Times of India Historical Archive (1838-2005), and Financial Times Historical Archive (1888-2010). The keywords used and dates during which these searches have been done can be made available, if needed. This systematic collection of data from secondary sources was done after completing data collection from primary sources.

After an initial screening of over 1,500 articles (from the four news databases), a total of 473 articles were used for coding and analysis. Apart from this systematic data collection from secondary sources, in-vivo data collection was done while transcribing the interviews and during fieldwork. In-vivo data collection is explained as follows: Internet search engine Google (including the News search) was used to look for specific articles that matched with keywords entered (these keywords were obtained while transcribing interview and during my fieldwork). For example, when Consultant Z said about certain difficulties faced by an informal-turned-formal processor in Delhi, we did a search on Google by typing the name of that firm to find out if there is any information reported. Apart from these, following secondary sources were also consulted: news articles from environmental magazines like Down To Earth (DTE); reports from Pollution Control Boards; reports by NGOs like GIZ, Toxics Link, Saahas, Chintan, SWaCH.

We adhered to the three principles of data collection suggested by Yin (2009). First, we used multiple sources of evidence to corroborate and augment evidence. The secondary sources of data used in the study helps to achieve this purpose. This provides multiple measures of the same phenomenon and helps to enhance *construct validity* i.e. stronger substantiation of constructs is achieved by triangulating data from multiple sources. Second, we created a case study database consisting of interview transcripts, direct observation & informal conversation, memos after each interview using a unique code for each data collection instance. Through this code, it is easy to trace the corresponding interview transcript, direct observation & informal conversation, and memo. Data from secondary sources were also kept separate in three folders: one folder for documents obtained from respondents; one folder for data collected (i.e. references) while doing transcription and fieldwork (i.e. in-vivo); one folder for data collected (i.e. references) systematically from news databases. All these different sets of data are kept separate from the final case analysis. This way of organizing data makes raw data available for independent inspection and *increases reliability*. Third, we have maintained a chain of evidence that links the initial research questions, conceptual framework, interview questions and procedures, citation to specific sources in case study database, raw data in the case study database, and final conclusions. This is to enable interested readers to trace the case study from conclusions to research questions or from research questions to conclusions (more information regarding this is described in the section on coding and analysis of data). This linkage from research questions to conclusions is achieved through proper citation of data in the case study report, accurately entering collected data in the case study database, and collecting data

according to stipulated procedures. Such linkages (or transparency) could be easily achieved by using NVivo software for storing and coding data. Thus, by adhering to these three principles of data collection, we have enhanced the transparency, construct validity, and reliability of this study.

3B.5 Coding and analysis of data

Data analysis is the "least developed and most difficult aspects" of case study research (Yin, 2009). The general analytic strategy we had was to rely on the conceptual framework developed before data collection. The data analysis technique appropriate for this case study is pattern matching (Barratt, 2011; Yin, 2009). This technique compares the hypothesized conceptual framework developed for understanding the e-waste RSC structure and formalization process to the empirically emerging RSC structure and formalization process.

Coding and analysis of data was done using NVivo software. Coding and analysis of data was done after completing the data collection from primary sources. The overall strategy of coding and analysis involved the following steps:

- Creating Nodes that are based on *a priori* propositions and emergent themes
- Coding data from the four sources into the relevant Nodes.
- Read contents of each Node and evaluate the proposition and emergent themes

The Node structure for understanding formalization process and e-waste RSC structure has been included in the Appendix 4 and Appendix 5. This is illustrated using the following example. For understanding the formalization process, consider Proposition 1: *Informal Processors process e-waste without any pollution abatement technology, protective equipment, and make profits*. This proposition was a created as a Node (Node name: *P1- Technology, Protective Equipment, & Profits*) in NVivo and all the relevant chunks of data, from the four data sources, pertaining to this proposition was coded into this Node. Similarly, separate Nodes were created for each proposition. For some Nodes, sub-nodes were made depending on the complexity of coding involved. We could have stopped the coding process by creating Nodes for each proposition. But, given the nature of exploratory qualitative research, there were emergent themes that seemed central to the phenomenon we are studying. For example, when an Officer at a Government Organization said about how the E-waste Rules originated, we did not have any *a priori* proposition that we could relate to. When the Joint Proprietor of Gamma,

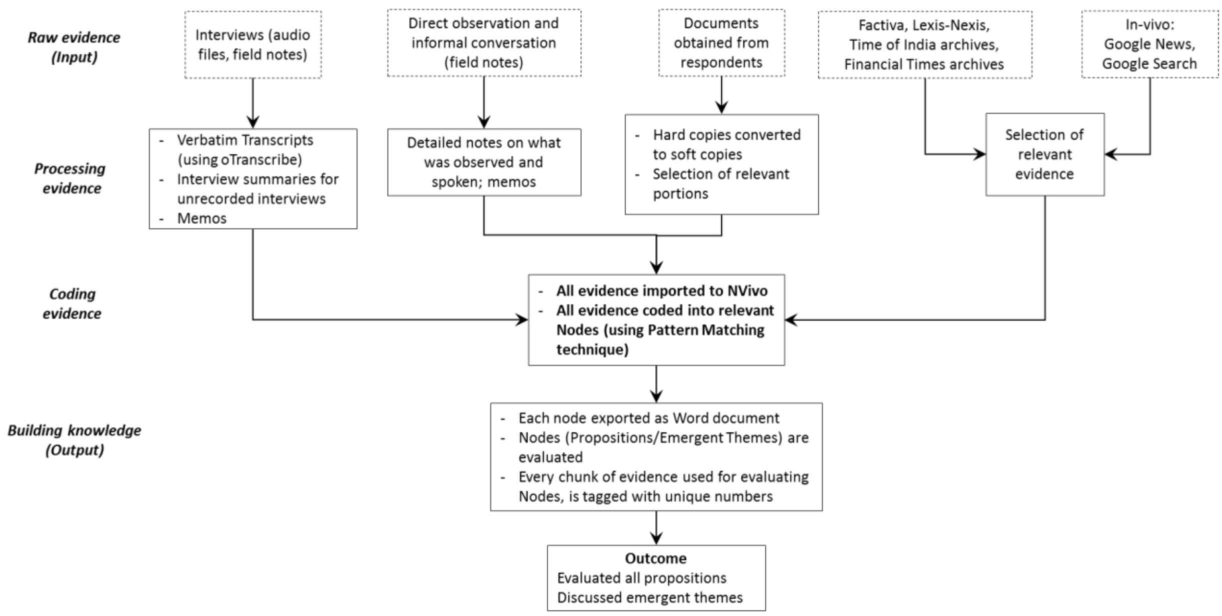
Consultant X, and Consultant Y revealed non-economic outcomes of formalization, we did not have any *a priori* proposition that we could relate to. When Consultant X said about the social ties and kinship in the community of informal processers, we did not have any *a priori* proposition that we could relate to. These were emergent patterns that were playing a central role in the phenomenon of interest. So, separate Nodes were created for these emergent themes. For example, the Node: *Origin of E-waste Rules 2011*, *Unique things about these recyclers*, *Other outcomes of formalization*, etc. were created based on the emergent themes. These emergent themes were not the result of an overnight thought. Through the course of data collection (spread over two years), these emergent patterns were noted down in the memos, and these patterns gained relevance and significance while interacting with more stakeholders during the fieldwork. Also, a considerable amount of time was spent *meditating* on what the respondents were saying and how to synthesize their perspectives. This meditation was done before coding and analysis phase. It is through such meditations that we realized the path dependence nature of e-waste RSC (while understanding the e-waste RSC structure) and created a Node to code all relevant data that was related to this concept. This kind of reasoning can be loosely called inductive i.e. these Nodes based on emergent patterns (that was derived inductively from the field) are outside the conceptual framework we had initially developed. This where Karl Weick's metaphor of a postcard, described in the previous chapter, makes a lot of sense. The propositions we had developed before fieldwork, is the postcard. The portions of actual paintings in the art museum that are not reproduced well on the postcard, are the emergent themes.

Given the nature of this research, it is not easy for another researcher to code the same data. Having spent sufficient time in the field, the researcher is the only person who would know the nuances and if the relevant chunk of data is worth coding to a Node. Inter-rater reliability for assessing consistency in coding is not possible. However, we had done a first-cut coding of 12 propositions (based on interview data of few select stakeholders) for understanding Formalization. This was done before doing a full-fledged coding of all primary and secondary sources. This first-cut coding and the actual coding done was fairly consistent. These two versions of coding are stored and can be made available, upon request.

After creating Nodes (based on *a priori* propositions and emergent themes), all Nodes from NVivo were exported to Word document formats. Nodes based on *a priori* propositions were analyzed using pattern matching technique (Yin, 2009). For example, consider the Node

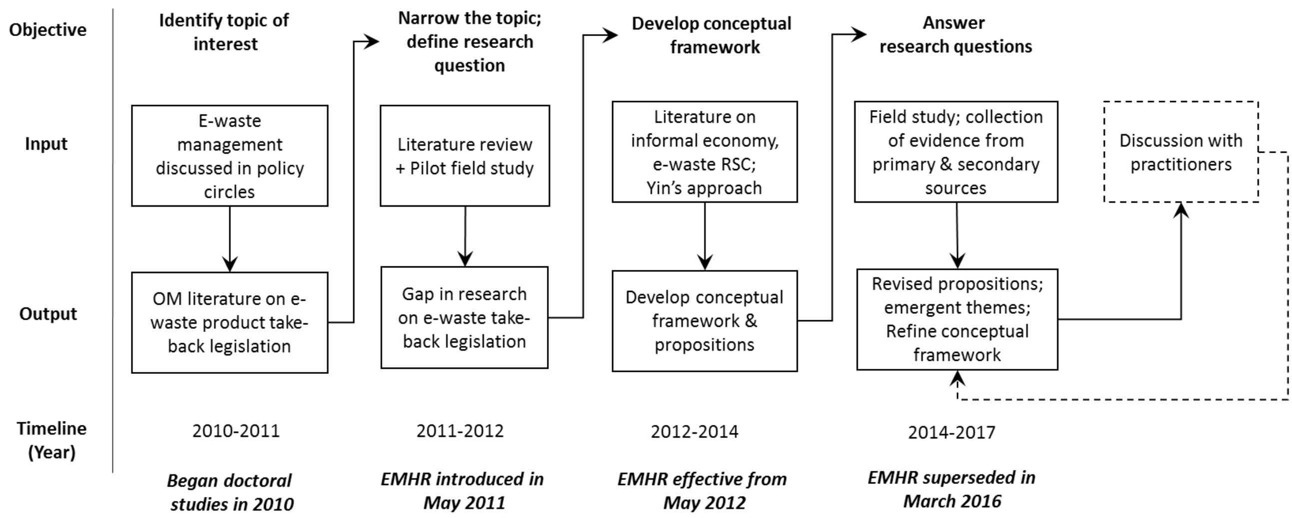
relevant to Proposition 1: *Informal Processors process e-waste without any pollution abatement technology, protective equipment, and make profits*. Based on the coded chunks of data from primary sources and secondary sources, this proposition was evaluated i.e. does the evidence obtained support this proposition? If evidence does not support, what could be the plausible reason why it does not support? This plausible reason, which emerged from the field, is further used to refine the proposition. For understanding formalization process, the unit of analysis (i.e. case) was informal-turned-formal processors while evaluating each proposition. Naturally, while coding all relevant chunks of data into a Node and while evaluating these codes chunks, cross-case analysis is inherent. Now, let us discuss how the Nodes based on emergent patterns were analyzed. For example, take the Node: *Other outcomes of formalization*. All relevant data that were pointing to non-economic outcomes of formalization were coded into this Node. While analyzing the coded contents of this Node, some concepts emerged like some firms were talking about increased social status, some firms were talking about lower happiness/increased tension, etc. These concepts that emerged inductively were developed into emergent themes. Figure 11 gives an overview of data collection and analysis.

Figure 11: An overview of data collection and analysis



An overview of our entire research process is illustrated in Figure 12, below. The dotted lines in this figure indicate an ongoing task. We have discussed this dissertation research and its findings with a few practitioners. Over a period of time, we have plans to meeting a few important respondents (who have contributed to this study) and presenting this research before them.

Figure 12: An overview of our entire research process[31]



Nature of process-oriented research

This study of formalization process and reverse supply chain, does not use variance models (econometric modelling based on numerical evidence). Variance models explain the variation in dependent variable on the basis of variation of independent variables and assume independent variables as necessary and sufficient conditions for the dependent variable to occur (Soh & Markus, 1995). In variance models, the time ordering in which independent variables combine is irrelevant (Soh & Markus, 1995). This study considers time ordering of formalization process, sequence of events or conditions that are necessary for formalization to be successful or unsuccessful. Such events are best understood using qualitative evidence.

While describing the formalization process, some propositions hypothesize regarding profits of informal-turned-formal firms. Numerical evidence of profits, revenues, etc. are not

[31] This style of presentation is adopted from Martinez et al. (2011).

available. This unavailability of numerical evidence is a characteristic of such small firms in the informal economy. These informal-turned-formal firms still do not maintain their accounts in IT systems or ledgers. This was told by Consultants from STIMULUS who have deep field experience working with them. It was also revealed that, when asked for these numerical evidence, informal-turned-formal firms would refuse to participate in our study. In such a situation, rather than removing the proposition (which would affect the conceptual framework), the next best option was to use surrogate measures. These surrogate measures are self-declaration by respondents regarding how well the firm is doing (i.e. qualitative evidence of profits) and direct observation from facility tours (i.e. what was going on in their processing facilities). For example, in one informal-turned-formal firm, the Proprietor said that his firm is doing well and he is able to make more money vis-à-vis informal. Direct observation from a tour of their facility revealed quality assurance certificates from reputed organizations hung on the wall, the shop-floor filled with printed circuit boards and employees completely occupied in disassembly and metal recovery, CCTVs (Closed Circuit Televisions) in the office room to monitor what employees operations in the shop-floor. Hence, this direct observation coupled with self-declaration by the Proprietor provided a reasonably confident evidence that firm is doing well i.e. in good economic condition. Scholars in OM have also taken similar approaches when obtaining numerical evidence was not possible in their research contexts[32]. For example, Done et al. (2011) took a similar approach by relying on self-declaration of respondents (i.e. qualitative evidence) regarding profits made by small-and-medium firms in United Kingdom. This is because such firms do not accurately collect and maintain numerical evidence of financial performance.

In this chapter, we explained the process of data collection and analysis. The evaluated propositions and emergent themes are discussed in Chapters 4 and 5. The next chapter provides a primer for reading Chapters 4 and 5.

[32] Management scholars (Christensen & Carlile, 2009) have also pointed out that even numerical data (if available) is subjective in nature i.e. numerical data is also an outcome of managerial discretion (prioritization, fudging, negotiation, etc.).

Chapter 3C: Primer for Chapters 4, 5

As discussed in the previous chapter, the evidence from primary and secondary sources were coded in NVivo i.e. Nodes were created in NVivo and relevant information from these sources were put into the Nodes. The propositions were evaluated after creating Nodes. So, while evaluating each proposition we have also provided a reference to the Node based on which the evaluation is done. For example, corresponding to Proposition 1, we have said "NVivo node: *P1- Technology, Protective Equipment, & Profits*". This means that the raw data that has been coded to the node pertaining to P1 can be found in the file named *P1- Technology, Protective Equipment, & Profits.doc*. These NVivo nodes were exported into Word documents and comment function was used to give unique reference numbers for various chunks of data ex: #1, #2, etc. For example, while evaluating Proposition 1, suppose the following quote is mentioned:

> *"Whatever recovery process we used to do i.e. extraction of gold, silver...we used to do recovery...this had chemicals, acid and all that...we used to work just like that...there were no machineries, personal protective equipments...without any safety, we used to work."* – Management Head of Beta (#12).

This means that, by opening the word document titled *P1- Technology, Protective Equipment, & Profits*, and going to comment #12, one will be able to see this raw data.

Sometimes, while evaluating propositions, we have used references from other Nodes wherever appropriate. For example, while evaluating a proposition, suppose the following quote is mentioned:

> Respondent A, reported the following: *"The health problems expressed by workers were head ache, abdominal pains, body pain, weakness, cough, depression. 4 workers smoke, all the 5 workers chew tobacco, 2 of them drink alcohol, 1 of them uses anti-depressants."* – (#2) [Other data on initial conditions].

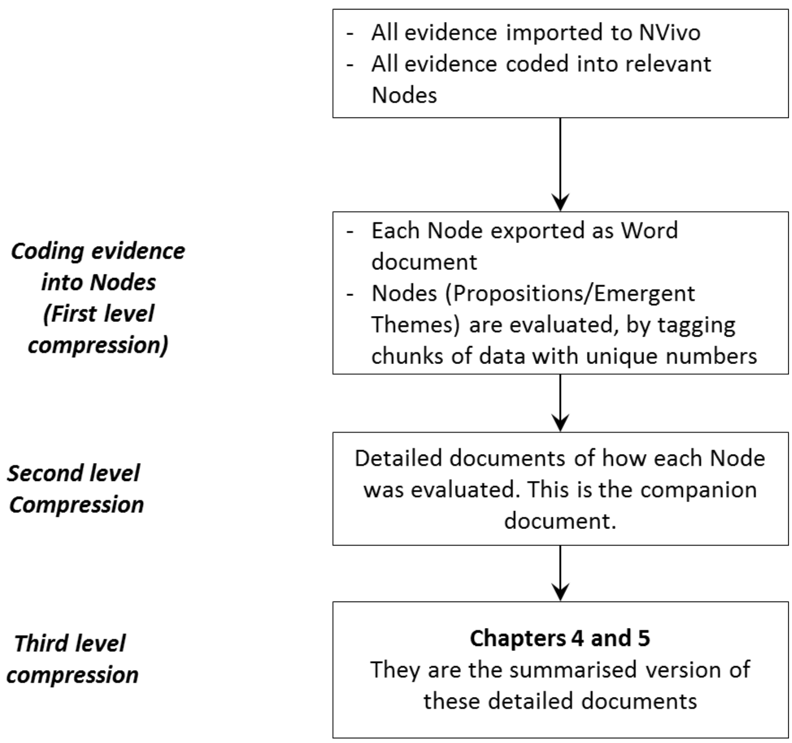
This means that, by opening the word document (Node) titled *Other data on initial conditions* and going to comment #2, one will be able to see this raw data.

This logic holds for the Chapter 4 on formalization and for the first two propositions (P1 and P2) of Chapter 5 on understanding e-waste RSC. From the third proposition (P3 and later) of Chapter 5, the comment #2 (or #X) means that if an external investigator opens the respective word document and goes to comment #2 (or #X), she will be able to see this raw data between #2 (or #X) and #3 (or #X+1). While evaluating propositions, we realized that the latter method is more efficient than the former.

Sometimes, while citing secondary sources (news articles, unpublished documents, etc.) for evaluating propositions, we have not mentioned the name of publication/author. This is to protect the respondents' and firms' identity. However, a comprehensive list of secondary sources (used for evaluating propositions) are included in Appendix 4 and Appendix 5. Name of publication/author of secondary sources (used for evaluating each proposition) can be easily retrieved through NVivo nodes, if needed.

The manner in which raw data is processed into Chapters 4 and 5 is explained in Figure 13, below. The companion documents (2nd level compression) and Nodes (1st level compression) can be made available, if needed.

Figure 13: An overview of the analysis process from raw data to Chapters 4 and 5

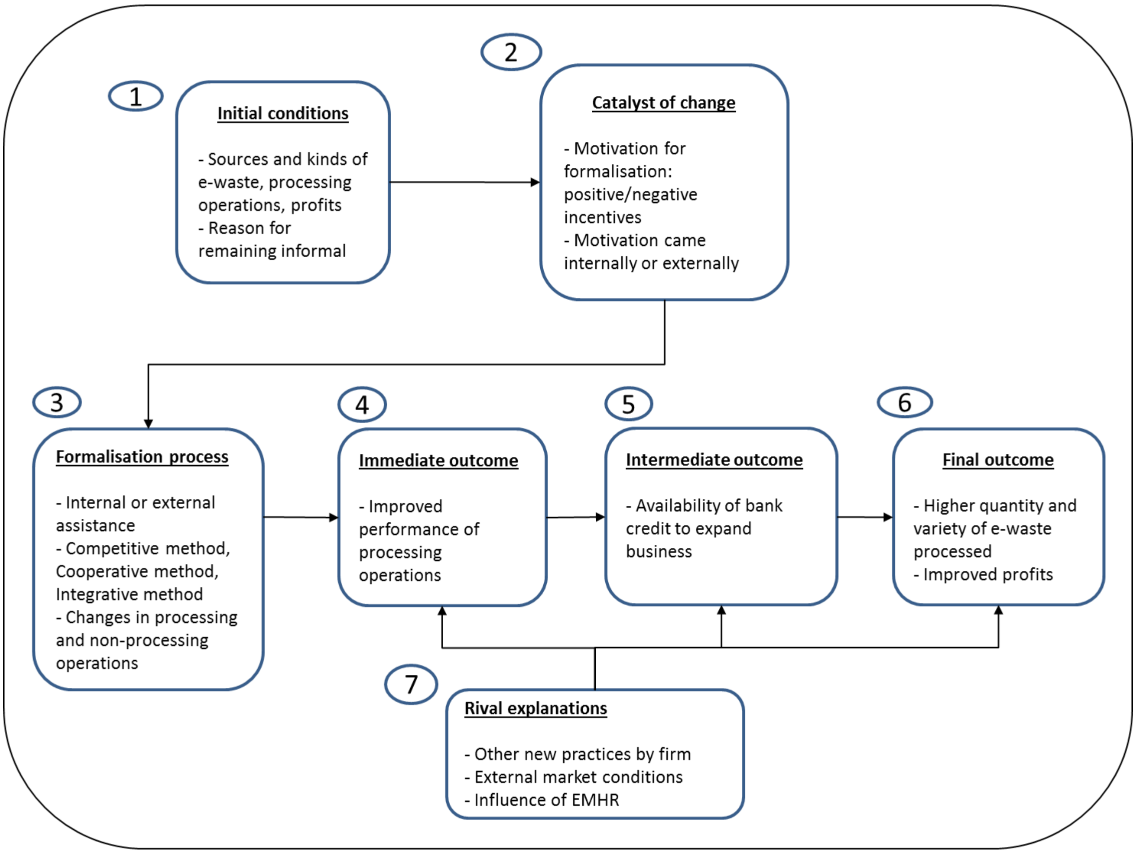


We have organized Chapters 4, 5 in such a way that each proposition or a set of related propositions begin in a new page. Chapter 4 and Chapter 5 evaluates propositions developed for formalization of informal processors and e-waste RSC respectively. These chapters also consist of sections based on emergent themes relevant to each chapter. Some sections in Chapters 4 and 5 do not contain the detail list of # (i.e. unique tagged numbers from 1st level compressed documents). This is done for better readability. In such cases, the companion document (2nd level compression) would have the necessary details.

Chapter 4: Formalization of informal e-waste processors

In this chapter, the conceptual framework developed in Chapter 3 is evaluated based on field evidence. The 12 propositions are evaluated and revised. In addition to this, three themes that emerged from the field are discussed. This chapter concludes by developing a revised conceptual framework (12 revised propositions and 3 emergent themes) and key findings of formalization study. The conceptual framework, developed prior to fieldwork, from Chapter 3 is reproduced below for providing continuity.

A conceptual framework of successful formalization process



Proposition 1

P1: Informal processors process e-waste without any pollution abatement technology, protective equipment and make profits.

Evidence from the field (NVivo node: *P1- Technology, Protective Equipment, & Profits*)

P1.1 Usage of pollution abatement technology and protective equipment

The informal-turned-formal firms processed e-waste without using any pollution abatement technology (i.e. machinery to collect or neutralize the toxic fumes and dust) and protective equipment (i.e. masks, goggles, helmets, gloves, and boots) while they were informal. This evident from comments #11, #12, #13, #15, #27, #28, #29, #31, #35, #36, #39, #40, #41. The extraction of gold, silver, etc. using acid and chemicals was done without using protective equipment like masks and toxic fumes were being inhaled (#12, #28, #29, #41). Dust emitted during e-waste disassembly used to enter their nasal cavity because there were no masks or technology used to suck and collect the dust (#27). For example, Joint Proprietor of Gamma spoke about his days in the informal economy without using any protective equipment:

"Before, we were eating the dust...dust was not only there, we were eating it", "we used to clean our nose in water, we used to eat bananas", "Bananas can take away all the dust from throat and elsewhere" – (#27).

Data from secondary sources corroborates this evidence obtained from primary sources. This evident from comments #1, #2, #3, #4, #5, #6, #7, #8, #9, #49, #52, #53, #54, #57, #58.

P1.2 Usage of pollution abatement technology during and after e-waste processing

Before developing this proposition, pollution abatement technology was hypothesized to be used only during e-waste processing. But, evidence from the field revealed an additional dimension i.e. usage of pollution abatement technology after e-waste processing. Unprocessed part of e-waste and by-products (ex: left-over acids after metal recovery) that are generated during e-waste processing are dumped along with municipal waste or in any public location without any treatment or neutralization. This is revealed from comments #20, #22, #42, #45.

For example, Joint Proprietor of Gamma said how the unprocessed part of e-waste was being disposed in the informal economy:

"If there was waste, we used to put in the corporation bins...the place where we work...after work, we used to sweep the remaining waste and put in municipal corporation dust bins" - (#20).

Data from secondary sources corroborates this evidence. This is evident from comments #1, #50, #51, #55, #56.

P1.3 Facility location

Facility location i.e. the facility (or place) where they processed e-waste while working in the informal economy, was not explicitly hypothesized as part of Proposition 1. Evidence regarding this emerged from the field. The informal-turned-formal processors worked on the street (roadsides), open yards (vacant public land), inside their homes, and in small rooms with low ventilation. These are revealed in comments #10, #14, #17, #26, #34, #38. For example, Management Head of Beta spoke about where they worked before becoming formal:

"That time, we did not work inside factory premises...if we got open space yard, we used to work there" - (#14).

Data from secondary sources corroborates this. This is evident from comments #5, #8. Interestingly, evidence from other informal-turned-formal firms obtained from secondary sources also points out that they worked in small rooms with very low safety & health concerns and in the backyard of their house (#58, #61). Importance of this understanding of facility location would be useful while evaluating Proposition 5(b).

P1.4 Occupational diseases and negative environmental externalities

E-waste processing in the informal economy without using pollution abatement technology (during and after processing), protective equipment located in facilities with poor health and safety measure plausibly leads to the following: (a) health problems for workers (ex: itching, cough, breathlessness, shivering of hands) (b) environmental pollution that impacts other people who are not involved in e-waste processing. This is revealed from the comments #15,

#27, #29, #34, #35, #40 and also corroborated by data from secondary sources (comments #2, #6, #9, #49, #51, #56; #2, #3, #4 from [Other data on initial conditions]). In economics, (b) is abstracted as negative environmental externalities. The health problems for workers are due to the nature of their occupation i.e. informal e-waste processing. This can be abstracted as occupational diseases which are an aspect of occupational health and safety. This distinction between both concepts was not well-understood while developing the proposition. Rather, this distinction emerged from the field evidence. A simple example would help to understand the seriousness of occupational diseases (#4) [Other data on initial conditions]. Employees at Alpha and Beta, prior to formalization, regularly consumed easily available tablets (normally prescribed for pregnant ladies) for reducing abdominal pains. For decongestion of respiratory tract, they used to sniff glue, whiteners, etc. They also ate bananas during their working hours which helped to ease discomfort in throat and food pipe.

P1.5 Informal-turned-formal firms made profits while working in the informal economy

There is evidence that they were *earning enough* money, *happily* doing business, *without any tension* in the informal economy (these italicized words were used by respondents). Specific evidence comparing profits (informal vis-à-vis formal) is covered in the forthcoming Proposition 11. They used manual processes for disassembly and metal recovery; machinery or pollution abatement technology were not used; they did business without using bills and paying taxes; they did not have to pay rents for the facility because they worked on the roadsides or in their homes. If at all there were rents, it was minimal i.e. they would pay a small amount to use their friend's shop for a day or two to process e-waste. Overall, their fixed costs were low. Whenever they purchased a consignment of e-waste, labour was hired for working on that specific consignment. These are revealed in the comments #12, #19, #21, #24, #25, #30, #32, #33, #37, #43, #44. For example, Joint Proprietor of Gamma spoke about how much he earned while in the informal:

"It was good...get material for 50,000 rupees...earn 5,000 rupees for the day...and it was enough for us", "We were happy when we used to get 5,000 rupees...we could eat peacefully for 5-10 days" - (#19)

Consultant Y spoke about the overall economic condition of these firms while they were in the informal economy:

"Even before [before formalizing] they used to wear good clothes, first-class cooling glasses, everyone had vehicle, LCD TV, everyone had good mobile, everything was there" – (#43).

Data from secondary sources that reported the economic condition of other informal-turned-formal processors, while they were in the informal economy, corroborates this evidence (comments #59, #60).

Evaluation: Overall, support was found for Proposition 1 (vide P1.1, P1.2, P1.5). However, more evidence emerged from the field (vide P1.3, P1.4) that led to a nuanced understanding of Proposition 1. This proposition is revised as follows in Table 17.

Table 17: Evaluation of Proposition 1

Original proposition	*P1: Informal processors process e-waste without any pollution abatement technology, protective equipment and make profits.*
Revised proposition	*P1 (a): Informal processors process e-waste without any pollution abatement technology, protective equipment, and make profits* *P1 (b): Pollution abatement technology is not used during and after e-waste processing* *P1 (c): Informal e-waste processing leads to occupational diseases and negative environmental externalities*

P1 (c) should not be construed in a causal sense. The purpose of P1 (c) is to delineate the negative impacts of informal e-waste processing into two concepts: occupational diseases and negative environmental externalities. Whether informal processing actually leads to such negative impacts (i.e. establishing causality) would be a separate study and is not part of this research design.

Proposition 2

P2: Informal processors do not formalize because they perceive formalization to involve higher processing costs and consequently reduced profits.

Evidence from the field (NVivo node: *P2- Why they were informal*)

The informal-turned-formal firms were not aware about the occupational diseases and negative environmental externalities of e-waste processing, while they were working in the informal economy. Even if some of them were aware, they did not care about these issues because this informal way of working was the only known occupation to them. They were not aware of what becoming a formal processor meant. They had not even heard terms like "formal" and "informal". In addition to this, legislation regarding e-waste processing (EMHR) did not exist until 2011. So, informal e-waste processing was not illegal[33]. Until the NGOs and Government conducted a survey on their unscientific/unsafe processing operations and termed them "informal", this distinction between informal and formal e-waste processing did not exist. This is an interesting insight which suggests that e-waste processing in the informal economy was "a way of living" for them. These are evident from the comments #1, #2, #3, #4, #5, #6, #7, #8, #9. This evidence reveals that the concepts of informal and formal are mere social constructs i.e. created by the society. It was hypothesized in the proposition (based on extant literature in economics) that informal processors do not formalize due to perceived higher costs. But, field evidence suggests that these concepts of informal and formal did not even exist! The informal processors did not even know that they were "informal".

The evidence described above, was the situation in early-2000 and mid-2000 when e-waste awareness was at its infancy. But, the current situation (at the time of this fieldwork) is different. Currently, all informal e-waste processors (who have not formalized yet) are aware about formalization, EMHR, and environmental pollution. This is evident through informal conversations with informal processors who attended stakeholders' meetings. All these informal processors have not formalized yet. For example, Proprietor of VET (an informal e-waste processor) said that though he can invest Rs. 30 lakhs to set-up a formal firm, costs are

[33] As per the Hazardous Waste Management Rules 2008, it is not entirely accurate to claim that informal e-waste processing was not illegal prior to 2011. However, the response obtained from stakeholders were with respect to the year before 2008. The previous versions of Hazardous Waste Management Rules (in 1989, 2000, 2003), did not cover e-waste.

high and proportionate revenues cannot be generated to earn profits. Informal Processor B was previously a Joint Proprietor of Gamma. Later, he left Gamma and returned to do e-waste processing in the informal economy because he was not able to earn enough profits. These evidence, based on the current situation, suggests that informal processors perceive formalization to involve higher processing costs and consequently reduced profits.

Evaluation: Evidence from the field led to two categorizations based on the growth stage (industry lifecycle) of the e-waste processing industry. Support for this proposition was found from informal processors who have "been there and seen everything" i.e. informal processors who continue to exist during the later stage of this industry. No evidence was obtained to support this proposition from informal processors who existed in the early stage of this industry when the terms "informal" and "formal" did not exist. This categorization has helped to get a more nuanced understanding of this proposition. This proposition is revised as follows in Table 18.

Table 18: Evaluation of Proposition 2

Original proposition	*P2: Informal processors do not formalize because they perceive formalization to involve higher processing costs and consequently reduced profits.*
Revised proposition	*P2 (a): In the early stage of this industry, the terms informal and formal did not exist* *P2 (b): Informal processors, in the early stage of this industry, did not formalize because such concepts did not even exist and it was their "way of living"* *P2 (c): Informal processors, in the later stage of this industry, did not formalize because they perceive formalization to involve higher processing costs and consequently reduced profits.*

Proposition 3

P3: External intervention motivated informal processors to formalize by showing the potential for more profits after formalization.

Evidence from the field (NVivo node: *P3- Catalyst of change*)

P3.1 External intervention occurred and initiated formalization

Intervention by STIMULUS (i.e. external intervention) gave awareness to informal processors about occupational diseases and negative environmental externalities due to informal method of e-waste processing. STIMULUS also made them aware of the forthcoming legislation (i.e. EMHR) that would mandate all bulk consumers to dispose e-waste only to formal e-waste processors. However, this intervention was not an easy task for STIMULUS. Initially, the informal processors had apprehensions regarding STIMULUS i.e. would STIMULUS steal their processing knowledge? Whether STIMULUS included officials from Income Tax Department, etc. Consultants from STIMULUS secured the trust of informal processors by engaging with them in the field for around a year. Once the informal processors recognized the noble intentions of STIMULUS, they cooperated by listening to what STIMULUS had to say and by attending their training programmes. This is evident from comments #1, #31, #2, #3, #5, #19, #23, #25, #26, #27, #28, #29, #30, #31, #33, #34. This is also corroborated by data from secondary sources (comments #40, #41).

P3.2 Informal processors were not motivated to formalize by realizing the potential for making more profits after formalization

Evidence could not be obtained to support the proposition that informal processors decided to formalize due to higher expected profits. Rather, the evidence from the field reveal that informal processors were motivated to formalize due to three reasons:

(a) Reluctantly formalized (without purely profit expectation): The e-waste legislation (EMHR) was forthcoming while STIMULUS was providing awareness to informal processors. Many bulk consumers who were disposing e-waste to informal processors, started asking for the authorization (or certificate) from Government (i.e. Pollution Control Board) i.e. they began

considering formal e-waste processors due to forthcoming legislation, reputational concerns, etc. Also, many bulk consumers started online auctions for e-waste disposal and it was impossible for informal processors to participate in these auctions due to lack of authorization (i.e. certificate). Informal processors realized that if they do not formalize, they will not be able to continue their business. On the contrary, if they formalize, they could bid for e-waste from reputed bulk consumers (i.e. MNCs) and also make long-term contracts with them. These are evident from comments #4, #6, #7, #9, #16, #17, #18, #20, #21, #22, #23, #34. Data from secondary sources corroborates this evidence of reluctant formalization (i.e. without a pure profit expectation) from comments #35, #38, #39, #40, #42, #43, #19 [Node: Other data on catalyst of change]. Forthcoming e-waste legislation, many bulk consumers deciding to give e-waste only to formal processors, etc. can be abstracted as changes in the external environment. Evidence from secondary sources also reveal that STIMULUS played an important role to influence the external environment (#40, #13 [Node: Other data on catalyst of change]). For example, STIMULUS initiated the creation of e-waste awareness campaigns to persuade bulk consumers not to dispose e-waste to informal processors. Apart from this, STIMULUS closely worked with the Government to introduce e-waste legislation that would mandate bulk consumers to dispose e-waste only to formal processors.

(b) Expecting incentives from Government: If they formalize, Government or STIMULUS will recognize their work and give them better facilities (ex: land, facility, etc.) to do e-waste processing. This evident from comments #1, #10, #28. This is also corroborated by evidence from secondary sources (#19) [Node: Other data on catalyst of change].

(c) Environmental and health concerns: They became aware of occupational diseases and negative environmental externalities due to informal e-waste processing through STIMULUS's intervention. This evident from comments #12, #13, #15, #17, #27. Though many informal-turned-formal processors said that protecting environment and health were the reasons why they became formal (comments #1, #3, #4 from [Node: Other data on catalyst of change]), these are politically correct responses and the underlying reason is either (a) or (b). For example, though Proprietor of Alpha initially spoke about environment, health motivation and the social service mind-set, during final stages of the interview he revealed that earning money is of top priority and environment, health comes at the bottom (#4) [Node: Other data on catalyst of change]. It is to be noted that the informal processors' intent is not to damage their health and environment. Their fundamental aim or intent is to secure livelihood, continue to do business, and earn money for their family.

A certain level of risk appetite is needed for an informal processor for making the shift to set-up business in the formal economy. This concept is not included in the theoretical framework of this study. Risk appetite, if included in future research, can serve a moderating variable between STIMULUS's intervention and decision by the informal processor to formalize.

Evaluation: Partial support was found for this proposition based on field evidence. It was found that external intervention (by STIMULUS) initiated this entire idea of formalization by giving awareness, training, etc. thereby supporting a part of this proposition (vide P3.1). But, informal processors were not motivated to become formal due to higher expected profits. Overall, there were many changes happening in the external environment (i.e. forthcoming e-waste legislation, bulk consumers deciding to give e-waste only to formal processors, etc.). It is primarily these changes in the external environment that motivated them to become formal (i.e. reluctantly formalized). This proposition is revised as follows in Table 19.

Table 19: Evaluation of Proposition 3

Original proposition	*P3: External intervention motivated informal processors to formalize by showing the potential for more profits after formalization.*
Revised proposition	*P3 (a): External intervention occurred and initiated formalization* *P3 (b): Informal processors were motivated to formalize due to two reasons:* - *Reluctantly formalized due to changes in the external environment* - *Expecting incentives from Government*

Proposition 4

P4: Formalization of informal processors is done using external help.

Evidence from the field (NVivo node: *P4- Formalization done using external help*)

P4.1 Informal processors received external help to formalize

There was external help to formalize the informal processors i.e. STIMULUS helped informal processors to formalize. This is evident from comments #1 to #82 (except #33) from primary sources. Though the Proprietor of Delta said that he did not receive any help from Government or NGO (#33), responses from Consultants X and Y reveal that they did provide help to Delta regarding preparing documents, naming the firm, etc. (#49, #51, #70). Detailed Project Report (DPR) of Delta which was prepared by an external agency, with the help of STIMULUS, and submitted to the Government (i.e. Pollution Control Board) was also obtained for verification (#10). Using these evidence from multiple sources (triangulation), it can concluded with some reasonable confidence that Delta did receive external help while getting formalized.

Data from secondary sources corroborates this. This is evident from comments #83 to #109.

P4.2 Nature and degree of external help

Initially, STIMULUS helped to form two charitable Trusts, Alpha Trust and Beta Trust, by bringing informal processors together and registering the Trust with Government. Beta Trust was made first followed by Alpha Trust. Each of them had 11 members who were independent informal e-waste processors. The major role played by STIMULUS was motivating them to form these Trusts. This helped informal processors to get themselves organized under the umbrella of Trust. This initiative of forming Trusts, gave confidence to the informal processors (i.e. they can get together and *do something*). Once the Trusts were formed, a few informal processors within each Trust made joint investments to set up a formal e-waste processing firm. Such joint investments helped to share the risk of a potential loss. This was the first time that an informal-to-formal transition was being planned and there was considerable uncertainty and ambiguity regarding the formalization process and the outcome (i.e. whether they would get

authorization or not after investing money and efforts). All these are evident from comments #47, #49, #52, #53, #54, #55, #56, #57, #64, #67, #73, #76.

STIMULUS hand-holded few informal processors, from each Trust, who made joint investments to set-up Alpha and Beta Recycling Companies Pvt. Ltd. Few members of Alpha Trust invested money to form Alpha Recycling Company Pvt. Ltd. Four members of Beta Trust invested money to form Beta Recycling Company Pvt. Ltd. The components of this hand-holding were as follows: site selection, preparing DPRs, filling and submitting Governmental forms and documents, coordinating with the Pollution Control Board, suggesting what pollution abatement technology to be installed, training on formal e-waste processing methods. After getting formalized, these firms were also given training regarding how to manage a business i.e. training in basic accounting, preparing brochures, marketing (i.e. how to approach customers), etc. These are evident from comments #47, #49, #52, #53, #54, #55, #56, #57, #64, #67, #73, #76. The formation of Alpha and Beta Trusts and later into formal processing firms is also corroborated by evidence from secondary sources. This is evident from comments #12, #17, #18, #19, #21, #22, #83, #88, #89, #91, #92, #94.

After Alpha and Beta firms were formed, other informal processors (also including people from Alpha and Beta Trusts) started thinking about setting up their own formal processing firm. For these informal processors, STIMULUS did not do any hand-holding. Formation of Trusts was not needed at this stage, because now the informal processors had gained confidence. The help given by STIMULUS was in preparing DPRs to be submitted to the Government and to help them in documentation. Degree of external help received by informal-turned-formal firms during formalization is summarized in Table 20.

Table 20: Degree of external help during formalization

Name of the firm	Degree of external help
Alpha	Very high; Hand-holding
Beta	Very high; Hand-holding
Gamma	Medium; Hands-off
Delta	Medium; Hands-off
Epsilon	Medium; Hands-off
Zeta	Medium; Hands-off

Even after formalization, whenever they need help, STIMULUS continues to help them in a facilitative role. But, they do not provide direct help like getting them access to reputed bulk consumers i.e. direct help to improve their business is not provided. But, conducting training programmes to improve sales and marketing skills, facilitating them to tour e-waste processing plants in Germany, etc. were done. This is evident from comments #27, #59, #41, #42, #43. This corroborated by evidence from secondary sources (#13).

The features of this external help are: external help is non-monetary and more of supportive or facilitative; external help is only from STIMULUS and not from Government.

Evaluation: This proposition is supported based on field evidence. More nuances (vide P4.2) are added to the existing proposition to help understand the phenomenon better. These nuances emerged from the field and were not hypothesized prior to fieldwork. This proposition is revised as follows in Table 21.

Table 21: Evaluation of Proposition 4

Original proposition	*P4: Formalization of informal processors is done using external help.*
Revised proposition	*P4 (a): Formalization of informal processors is done using external help.* *P4 (b): Nature of external help is non-monetary and facilitative which continues even after formalization.* *P4 (c): Degree of external help was very high for the first two informal-turned-formal firms when compared to other firms.*

Proposition 5 (a)

P5 (a): Formalization process involves installing prescribed pollution abatement technology for processing e-waste and obtaining authorization from the respective SPCB.

Evidence from the field (NVivo node: *P5(a)*)

P5a.1 Installing pollution abatement technology

During this formalization phenomenon, Government had not prescribed any specific pollution abatement technology (#60). Based on the existing Water Act, Air Act, and Hazardous Waste Rules, these firms were set-up and appropriate technology was decided jointly by the respective SPCB and STIMULUS (#60). Fundamentally, the pollution abatement technology consists of installing appropriate dust collector depending on whether the firm does disassembly or metal recovery. Dust Collectors are an integral component of general industrial machinery that collects dust and impurities from air released during processing operations. If the firm is planning to do only disassembly, fabric filter (a type of dust collector that uses fabric bags as filters to collect dust) is sufficient. If the firm is also planning to do metal recovery, it needs to have wet scrubber (a type of dust collector that uses liquid medium to collect dust), furnace, leak-proof tank to store acid, lab for storing the chemicals, acid-proof floor tiles coated with lapaxy, and effluent treatment plant (to treat left-over acids and dust-laden liquid from wet scrubber). Technically speaking, wet scrubber cannot be considered as a "dust" collector[34]. Wet scrubber collects the hazardous substances from gaseous emissions (fumes emitted during metal recovery). These gases are dissolved in a liquid medium (usually water), insoluble part will enter the active charcoal filer (where charcoal absorbs the gases) and clean air is emitted. The soluble part is treated in effluent treatment plant.

P5a.2 Steps for obtaining authorization

Informal processor needs to follow a series of steps or activities for obtaining authorization i.e. to become a formal firm. It is through these series of steps or activities the firm moves from

[34] We thank the Co-founder of RWM for this explanation of wet scrubber.

informal to formal. Hence, these steps can also be considered as formalization process. The sequence of steps for obtaining authorization is summarized in

Table *22*.

Table 22: Summary of authorization/formalization process

Step No.	Details of each step in the formalization process
1	- Search for land in industrial area approved by Government - Secure land through rent or lease or purchase and have it documented
2	- Obtain VAT, TIN registration - Make the firm a private limited company - Obtain SSI certificate
3	- Prepare DPR (details regarding proposed company; planned capacity; organizational structure; facility layout; use of lighting, ventilation, water, toilet, septic tank; how e-waste processing would be done; pollution abatement technologies installed; occupational safety measures) - Fill forms for Air Act and Water Act
4	Apply to respective SPCB with these documents (mentioned in Step 3), by paying a fee
5	Officials from the respective SPCB inspects the land and facility, and gives CFE (Consent for Establishment) after a committee meeting among officials at the respective SPCB. Obtaining CFE means that the firm can go ahead and establish the full-fledged e-waste processing facility.
6	- Install appropriate pollution abatement technology - Obtain assessment report from the respective District Industries Center - Obtain Effluent Treatment Plant certificate if the firm is planning to do metal recovery
7	- Apply to respective SPCB with all the documents (mentioned in Step 6) by paying a fee - Pay Rs. 1 lakh as security deposit
8	Officials from the respective SPCB inspects the facility, and gives CFO (Consent for Operation) after a committee meeting among officials at the respective SPCB. Obtaining CFO means that the firm is authorized by Government (i.e. becomes a formal firm) and can do e-waste processing business. The firm also gets a passbook on which details of buying (inflow of e-waste) and selling (outflow of recyclables) needs to be entered.

Step 1 to Step 4 needs to be completed to realize Step 5. Steps 5, 6, and 7 needs to be completed to realize Step 8. This summary of formalization (including P5a.1) has been synthesized using evidence from informal-turned-formal firms and Consultants from STIMULUS (comments #1, #2, #3, #44, #46, #47, #48, #49, #50, #51, #52, #57, #58, #61- #68). This is also corroborated by evidence obtained from DPRs of Alpha, Beta, Gamma, Delta, Epsilon, and Zeta (comments #4 - #34) and other secondary sources (#80 - #83).

P5a.3 Capacity planning for informal-turned-formal firm

This concept was not hypothesized as part of the proposition. Interesting insights about planning appropriate capacity emerged from the field evidence. Traditionally, from the OM literature, it is evident that the firm plans its capacity. But, in this context of formalization, capacity planning is ad-hoc and jointly done by the informal firm (yet to be formalized) and the SPCB. For example, both Beta and Delta do disassembly and metal recovery, has the same number of employees, and has floor space of 1580 sq. ft. and 1200 sq. ft. respectively (#9, #12). Based on the floor space and experience of proprietors, the capacity was planned at 300 MT and 780 MT per annum respectively for Beta and Delta (#9, #12). This kind of capacity planning is ad-hoc and do not follow any codified logic. The informal firm plan capacity and submits this number in the application form (#59). Officials from the respective SPCB, while they inspect the facility, negotiate with the firm to finally decide and authorize the capacity (#57, #59). If the firm asks for capacity of X MT per annum, SPCB officials inspecting the facility will suggest and authorize a capacity less than X (#57, #59). For example, Product Take-back Manager of LED said regarding this joint capacity planning:

"If the recycler says 10,000 tonnes, Government will say 5,000 tonnes...the capacity is negotiated...there is subjectivity in arriving at this capacity." – (#59)

Recently, one SPCB developed a logic to plan capacity for formal e-waste firms in the respective State (#70, #71). A limit of 300 MT per annum was decided for firms who does only disassembly (manually, without using any expensive machinery), irrespective of the number of employees. The rationale behind this logic is to facilitate big formal firms to procure e-waste (#71). These big formal firms have made significantly higher investments (over Rs. 100 lakhs) with expensive machinery and pollution abatement technology to build their e-waste processing facility (#71). This ad-hoc capacity planning is applicable not only for informal-turned-formal firms, but for any firm that sets-up an e-waste processing business.

Evaluation: Partial support was found for this proposition. Formalization process involves installing appropriate pollution abatement technology (vide P5a.1). But, the specifics of this technology (i.e. technology standards) is not prescribed by Government (vide P5a.1) i.e. MoEF. Obtaining authorization from the respective SPCBs is 8-step process which essentially implies starting a new firm from scratch. Previous experience in similar business does not matter to obtain authorization. Irrespective of whether the applicant is an informal processor or not, they

will have to follow the same process for starting a formal e-waste processing firm. In light of this nuanced understanding, this proposition is revised as follows in Table 23.

Table 23: Evaluation of Proposition 5 (a)

Original proposition	*P5 (a): Formalization process involves installing prescribed pollution abatement technology for processing e-waste and obtaining authorization from the respective SPCB.*
Revised proposition	*P5 (a1): Obtaining authorization from the respective SPCB is a 8-step process which also includes installing appropriate pollution abatement technology*. *P5 (a2): There are no technology standards for pollution abatement technology, prescribed by the Government.* *P5 (a3): Appropriate pollution abatement technology is dependent on whether the firm does disassembly or metal recovery or both.* *P5 (a4): Capacity planning is ad-hoc and jointly decided by the firm and SPCB*

Proposition 5 (b)

P5 (b): Formalization is supposed to eliminate negative externalities during e-waste processing.

Evidence from the field (NVivo node: *P5(b)*)

Negative externalities were separated into two concepts: occupational diseases and negative environmental externalities (vide Proposition 1(c)). It was found that formalization helps to minimize (and not eliminate) occupational diseases and negative environmental externalities through installation of pollution abatement technology and other procedures (vide Proposition 7(b)). This is summarized in Table 24.

Table 24: Formalization's relation with occupational diseases and negative environmental externalities

Procedures related to formalization	Impact on health and environment
- Hand operated power tools minimize accidents - Fabric filters collect dust generated during disassembly - Wet scrubber extracts acid fumes and cleanses the air - Use of Personal Protective Equipment (gloves, masks, helmet, goggles) while processing e-waste; first-aid kits and first-aid chart; fire extinguishers; a chart depicting contact details of nearest hospital, fire station	Minimizes occupational diseases
- Solid waste stored in separate bins and disposed of as municipal waste - Waste water (or effluent) is treated and later released to public sewer - Hazardous waste generated (dust from fabric filters, wet scrubbers and sludge from effluent treatment) is stored in high-density polyethylene sealed containers and given to TSDF	Minimizes negative environmental externalities

This table presented above was synthesized from the evidence obtained from the Joint Proprietor of Gamma (#37) and DPRs prepared by Apha, Beta, Gamma, Delta, Epsilon, and Zeta. It is to be noted that there are some commonalities between the two. For example, using wet scrubber or fabric filter not only protects the employee from inhaling toxic acid fumes or dust, it also prevents toxic fumes or dust from getting released into the surrounding environment. This helps minimize occupational diseases and negative environmental externalities.

Evaluation: This proposition is supported based on field evidence. Formalization is theoretically supposed to minimize two things: occupational diseases and negative environmental externalities. One important point to be noted is formalization does not automatically guarantee this minimization. The onus is on the employees to comply or adhere with formalization related standards/procedures to minimize occupational disease and negative environmental externalities (more evidence regarding this is explained in Proposition 7(b)). This proposition is revised as follows in Table 25.

Table 25: Evaluation of Proposition 5 (b)

Original proposition	*P5 (b): Formalization is supposed to eliminate negative externalities during e-waste processing.*
Revised proposition	*P5 (b1): Formalization is theoretically supposed to minimize occupational diseases and negative environmental externalities during and after e-waste processing.* *P5 (b2): This is assuming firms' adherence with formalization related standards.*

Proposition 6

P6 (a): There are three methods to formalize: competitive, cooperative, and integrative.

P6 (b): Informal processors choose competitive method if economic value, quantity, and frequency of e-waste supply is high.

P6 (c): Informal processors choose cooperative method if economic value, quantity, and frequency of e-waste supply is low.

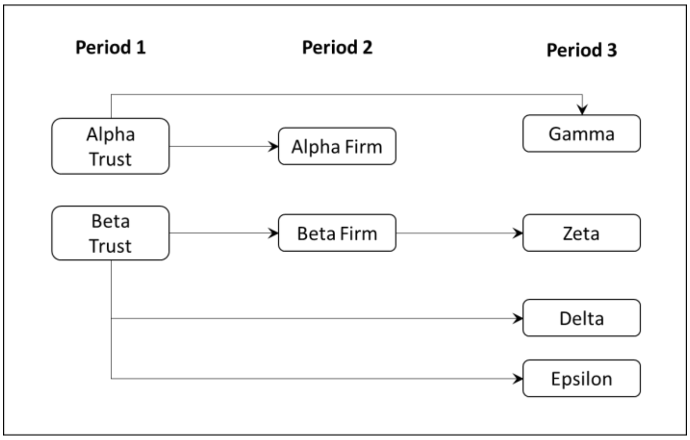
P6 (d): Informal processors choose integrative method if economic value is low but quantity and frequency of e-waste supply is high.

Evidence from the field (NVivo node: *P6- Methods to formalize*)

P6.1 Methods to become formal

While evaluating Proposition 4 (vide P4.2), it was found that the initial informal-turned-formal firms were established after forming respective Trusts (Alpha Trust and Beta Trust). Initially, few informal processors who were part of these Trusts jointly set-up Alpha and Beta firms. Later, after seeing the successful (not in a financial or profit sense) formation of these firms, other informal processors of Alpha and Beta Trusts set-up firms without forming Trusts. In some cases, people who were part of these informal-turned-formal firms parted ways to set-up new firms. This overall method of formalization is illustrated in Figure 14.

Figure 14: Method of formalization for informal-turned-formal firms



There are more dynamics happening which are not illustrated in Figure 14. First point to be noted is that these firms are made through joint investments i.e. partnership and joint proprietorship. Though a sole proprietor for each firm would be mentioned in DPRs and elsewhere, this does not mean the entire investment is made by this sole proprietor. Other informal processors have invested along with this sole proprietor. As illustrated in Figure 14, initially (during Period 1) Alpha and Beta Trusts were formed. Both the Trusts had 10-12 members each. From these Trusts, Alpha and Beta firms were created in Period 2. Members of the Trust did not automatically become proprietors of Alpha and Beta firms. For example, only 4 members from Beta Trust became proprietors of Beta firm. Later in Period 3, more firms were established. Out of these 4 people of Beta firm, three quit and started their own formal firms (#2, #3, #5). For example, Proprietor of Zeta was part of Beta firm (#2, #4, #11), Proprietor of Delta was part of Beta Trust (#11), another member who started a firm that does disassembly and metal recovery was also part of Beta Trust (#11, #3). Few proprietors of Gamma were initially part of Alpha Trust (#12). All members of Alpha and Beta Trust have also started their own formal firms in Period 3 (#4, #11, #10). Recently, one of the joint proprietors of Delta quit and started another firm that does disassembly (#1, #13). Thus, evidence from the field supports a cooperative method of formalization in the initial stages (i.e. Period 1 and Period 2). Later in Period 3, methods to become formal is characterized by a combination of spin-offs and competitive method. Also, throughout these Periods, informal processors jointly invest to create formal firms (i.e. presence of an overall cooperative method to become formal). This field evidence is in stark contrast with the logic hypothesized in Proposition 6. Another interesting observation in Figure 14 is spin-offs from Alpha Trust (i.e. firms that were started by members from Alpha Trust) majorly does disassembly, while spin-offs from Beta Trust majorly does metal recovery. This is due to the differing ancestral origins of Proprietors of Alpha and Beta (this is explained in Theme 2 of Chapter 4, after evaluating all the propositions).

Though we found evidence for competitive method of formalization (creating of Gamma, Delta, Epsilon, Zeta in Period 3), this notion of competitive method is not as hypothesized. The competitive method hypothesis, as developed in the proposition, was without the spin-offs concept. The notion of competitive method obtained from the field is not in the strict sense of competitive i.e. the informal-turned-formal firms do not “fiercely” compete with one another. All these firms and their proprietors belong to the same religion (Muslims), reside in the same neighborhood, speak the same dialect (Dakhini Urdu), and worship in the same mosque. For

example, Informal Processor A and Joint Proprietor of Gamma stay in the same apartment. They said that other informal processors and proprietors of other informal-turned-formal firms also stay nearby (i.e. in the same neighborhood). Sometimes, e-waste purchased by one firm (or informal processor) is shared with other firms (or informal processors), during auctions by the bulk consumer these firms would collude and arrive at a consensus on who will bid the highest amount, etc.

Evidence from secondary sources supports the possibility of competitive method to become formal (#17). The firm Mash was created by one informal processor (all by himself) without cooperating with any other informal processor (#17). Mash is currently more focused on reuse, repair, and refurbishment. While in the informal, Mash has been involved in all processing operations including disassembly and metal recovery. But, no evidence was obtained from primary sources to deeply understand the formalization of Mash. Hence, there is evidence that weakly supports the possibility of competitive method to become formal.

Evidence from primary sources also revealed the possibility of integrative method of formalization, though this method was never materialized (#14, #16). But, the formal processor was not willing because they feared informal processors would recover high-value items from e-waste and give the remaining low-value items to the formal (#14). However, evidence from secondary sources reveal an integrative method of formalization. This evidence is based on an informal-turned-formal processor in Delhi that only collects e-waste and sells to formal processors. But, this method is not natural and it emerged due to legislative barriers that banned e-waste disassembly within the city (#28) [Node: Any info. for formalization chapter]. Hence, there is no evidence that supports the possibility of integrative method to become formal. However, an interesting variation of the integrative method was observed in the field. This is called the Quartz Project where the informal processors disassemble e-waste, take out PCBs, and sell them to a big formal processor who further sells them to a precious metal refiner. Quartz Project is explained in Theme 5 of Chapter 5.

P6.2 Conditions to choose an appropriate formalization method

A summary of field evidence is illustrated in Table 26.

Table 26: Characteristics of e-waste supply before formalization

Firm	Characteristics of e-waste supply before formalization				Method of formalization
	Sources	Type*	Quantity	Frequency	
Alpha	Bulk consumers, PCMs	Telecom (2%), Computers & Peripherals (70%), Electrical panels/drives (10%)	500 MT per annum	Once or twice per month	Cooperative
Beta	Bulk consumers, PCMs	Telecom (30%), Computers & Peripherals (25%), Electrical panels/drives (15%)	High	Ad-hoc, Monthly once	Cooperative
Gamma	Bulk consumers, PCMs, Auction firms	Telecom (2%), Computers & Peripherals (70%), Electrical panels/drives (10%)	1MT-10MT in a single deal	Daily, Monthly twice, 15 days/month	Spin-off; competitive
Delta	Scrap traders	Telecom (35%), Computers & Peripherals (25%), Electrical panels/drives (15%)	Enough (met the capacity)	Ad-hoc	Spin-off; competitive
Zeta	Bulk consumers, PCMs, Formal processors	Telecom (2%), Computers & Peripherals (70%), Electrical panels/drives (10%)	15-20 MT per month	Ad-hoc, 5 to 6 times a month	Spin-off; competitive

* This denotes the breakup of typical e-waste purchased by the firm at any point in time.

MT denotes Metric Tonne. 1 MT = 1,000 kg.

No discernable patterns could be drawn from the field evidence to evaluate Propositions 6 (b), 6 (c), and 6 (d). For example, Alpha and Beta had reasonably good quantity and frequency of e-waste supply. But, they still choose the cooperative method. At the face of it, this evidence falsifies the Proposition 6 (c). But, this proposition was developed without prior understanding of Trusts formation. All these firms are created by joint investments (i.e. cooperative in a larger sense).

Interesting point to be noted is all these firms, while in the informal, processed e-waste as and when such opportunities came up (i.e. e-waste was purchased on an ad-hoc basis). There was no fixed quantity or frequency or type of e-waste supply. They do not maintain such accounts. In general, they purchased any type of e-waste i.e. telephones, telecom; electrical panels/drives; personal computers & peripherals; ship equipment, UPS, batteries, stabilizers; electronic devices like ICs, resistors; medical equipment; wires, cables; and other miscellaneous items. The percentages of these e-waste types mentioned in the table should not be taken at face value. These percentages were obtained from the DPRs submitted to Government (DPRs were prepared by a third-party firm, arranged by STIMULUS, on behalf of the informal firms).

Evaluation: Overall, there is some support for Proposition 6 (a) (vide P6.1). In light of field evidence (vide P6.1 and P6.2), this proposition is revised as follows in Table 27.

Table 27: Evaluation of Proposition 6

Original proposition	*P6 (a): There are three methods to formalize: competitive, cooperative, and integrative.* *P6 (b): Informal processors choose competitive method if economic value, quantity, and frequency of e-waste supply is high.* *P6 (c): Informal processors choose cooperative method if economic value, quantity, and frequency of e-waste supply is low.* *P6 (d): Informal processors choose integrative method if economic value is low but quantity and frequency of e-waste supply is high.*
Revised proposition	*P6 (a): There are three methods to formalize: competitive, cooperative, and integrative.* *P6 (b): Informal processors formalize using a hybrid method that is simultaneously cooperative, competitive, and involves spin-offs.*

Proposition 7 (a)

P7 (a): In the immediate stage after formalization, costs of doing business increases and this decreases profits.

Evidence from the field (NVivo node: *P7(a)- Immediate stage (Costs and Profits)*)

Fixed costs comprises the following components (comments #2, #3, #5, #8, #10, #13, #15, #16, #19, #22, #24, #28, #31, #34, #37):

- Securing land in an industrial area. Constructing a facility which includes building, installing pollution abatement technology and other equipment. For example, constructing office room, fabricating or purchasing dust collectors, purchasing hand tools, PPEs, building toilets, septic tank, etc.
- Fees and security deposit to the respective SPCB; other legal formalities like VAT registration, SSI registration, etc.
- Salary for employees
- Sales & Marketing
- Interestingly, there is one important fixed cost component that has received little attention. After securing land, constructing facility, and paying fees & security deposit, the authorization does not come immediately. The firm has to wait for a certain period of time which sometimes takes up 2-3 years. During this time the investment is locked.

Variable costs comprises the following components (comments #4, #9, #18, #26, #27, #28, #30):

- E-waste purchase
- E-waste processing i.e. running the dust collector using electricity, using acid for metal recovery, use of lighting while doing dismantling, use of water in the facility, etc.
- Paying money to TSDF for disposing hazardous waste (generated during e-waste processing)
- Paying tax while purchasing e-waste and selling processed e-waste

Several components of these costs are not incurred in the informal. The costs incurred in the informal are as follows: zero to minimal rents for the facility on a daily basis, daily wages for workers (i.e. hire-and-fire labor), and e-waste purchase costs (without paying taxes). A

summary of fixed costs (primarily including land, facility, and fees & other documents) incurred by various firms is included in Table 28. This table also includes information regarding revenues immediately after formalization. It is more fruitful to focus on revenues than on profits, in the immediate stage.

Table 28: Fixed costs and revenues in the immediate stage after formalization

Name	Fixed costs (in lakh rupees)	Revenues
Alpha	14-18	Nil. Not able to purchase e-waste.
Beta	≤ 25	Nil. Not able to purchase e-waste.
Gamma	30-40	Nil. Not able to purchase e-waste.
Delta	12	Purchased e-waste from one bulk consumer. This covered Delta for 6-7 months.
Zeta	17-20	Nil. Purchased e-waste from one bulk consumer. Waiting to purchase more e-waste to start processing.

Evaluation: It is evident from the above evidence that costs of doing business (fixed and variable) increased for all firms and revenues were nil for Alpha, Beta, Gamma, and Zeta due to lack of e-waste purchase. These firms were not able to purchase e-waste due to bulk consumers "sitting" on their purchase requests, difficulty in marketing and reaching out to bulk consumers. While Delta was able to purchase e-waste using his previous contact, Zeta is waiting for economies of scale for processing. Only Delta did not have any problem in purchasing e-waste, immediately after formalization. One explanation is Delta was lucky to be at the right place, at the right time. Before becoming formal, Delta was doing business with a telecom firm and during the time Delta became formal, there was a shift from 2G to 3G in the spectrum market (i.e. change in the external environment). This facilitated Delta to purchase the India-wide e-waste (i.e. 2G towers, servers, etc.) of the telecom firm. This proposition is revised as follows in Table 29.

Table 29: Evaluation of Proposition 7 (a)

Original proposition	*P7 (a): In the immediate stage after formalization, cost of doing business increases and this decreases profits.*
Revised proposition	*P7 (a1): In the immediate stage after formalization, costs of doing business (fixed and variable) increases* *P7 (a2): In the immediate stage after formalization, revenues are zero due to lack of e-waste purchased (under stable external environment)*

Proposition 7 (b)

P7 (b): In the immediate stage after formalization, the efficiency of processing operations improves and negative externalities are eliminated.

Evidence from the field

P7b.1 Impact of formalization on efficiency (NVivo node: P7(b)- Efficiency)

Earlier, while doing disassembly on the roadside by hammering e-waste and squatting on the road, small parts and screws used to go here and there (#8, #10). Now, after becoming formal, disassembly is done on a worktable by sitting on a chair using tools like screw drivers for disassembly (#8, #10). Small parts and screws are put in one of the bins placed near the work table, which are later sold in the market (#8, #10). This improves resource efficiency. Interestingly, evidence from the field revealed that it is not possible to process higher quantities of e-waste per day after becoming formal (#11, #12, #13, #9). Earlier, 3 people together could process 10 tons e-waste per day. But, now it is not possible. Earlier, they were working on the roadside, hitting e-waste on the ground or using a hammer for disassembly. But, now inside the formal facility they cannot do that. They have to sit on a table and disassemble using screw drivers and other tools. If they hit the e-waste on the floor, the floor tiles will break. Thus, evidence from primary sources reveals two ways to look at efficiency: (A) They are not able to process more e-waste per unit time after becoming formal i.e. lower throughput (B) Within whatever e-waste is processed, they are able to get more value out of it i.e. higher resource efficiency.

P7b.1 Impact of formalization on occupational diseases and negative environmental externalities (NVivo node: P7(b)- Negative externalities)

Occupational diseases reduce because of the use of fabric filters & wet scrubbers (for collecting dust and acid fumes) and PPEs. Negative environmental externalities reduce due to location of factory in an industrial area (away from their homes/residential areas), disposal of hazardous waste to TSDF, and neutralization of acids used for metal recovery before releasing to the sewer. This is evident from comments #9, #10, #13, #16, #17, #19, #20, #21, #22, #24 – 27, #45, #46, #47, etc. For example, Joint Proprietor of Gamma said:

"Here, we don't need to eat bananas...we don't need to clean our nose in water anymore" – (#22).

This is not to claim that formalization has completely nullified occupational diseases. Though there does exist some negative impact of the employees' health, it is less when compared to the situation before formalization (#32, #33). Pollution abatement technology or PPEs cannot guarantee 100% protection (#32, #33). This evidence is consistent with the findings of toxicology scholars who studied formal e-waste processing in different country contexts (Ceballos & Dong, 2016; Julander et al., 2014). They reported high levels of toxic metals in blood, urine, and plasma of employees working in formal e-waste processing facilities in countries like China, Sweden, USA, etc. This is plausibly due to lack of adherence to formalization standards (Ceballos & Dong, 2016).

Facility tours confirmed the existence of worktables, pollution abatement technology, and PPEs at the facilities of Beta, Gamma, Delta, and Zeta (#1, #5, #6). Sometimes, the incentives are such that the informal-turned-formal firm choose not to do processing operations in the formal way. This is evident from comments #1, #2, #34, #4, #40, #42, #48. For example, in spite of having a dust collector (i.e. fabric filter or wet scrubber), it is not switched on while processing e-waste (to save electricity expenses). They find it comfortable to do disassembly by squatting on the floor rather than sitting on a chair and using the worktable (dust collector will work only if the disassembly is done on the worktable). In such situations, occupational diseases will not reduce and negative environmental externalities become concentrated in the industrial area (no immediate effect on environment/people in the residential area). It was observed while touring Gamma's shop floor, that employees sat on the floor and disassembled printed circuit boards by bare hands using hammers and pliers (#1). In another case, the Proprietor of Alpha opened up regarding adherence to the formalization process:

"We are not getting profits due these various costs...we have no option other than to flout the guidelines...who cares for the environment, if you cannot make profits. For example, we let the unprocessed hazardous waste down the municipal drainage…because, we have to pay money to TSDF to take this." – (#2).

But, these firms do e-waste processing in the formal way (i.e. adheres to formalization standards) during inspections by external organizations like Government or STIMULUS (#42).

This establishes that there exists opportunities for gaming-the-system and some firms take advantage of these opportunities by choosing not to adhere with formalization standards.

Evaluation: Though overall support was found for this proposition, certain nuances emerged from the field (vide P7b.1 and P7b.2) that enriches this proposition. For example, evidence from the field led to two dimensions of efficiency (vide P7b.1). Field evidence also led to an important concept (i.e. adherence to formalization standards) that moderates the impact of formalization on occupational diseases and negative environmental externalities (vide P7b.2). This proposition was developed by assuming immediate stage after formalization. But, while evaluating P7 (a), it was evident that these firms could not purchase e-waste under normal external business environment. So, e-waste processing has happened in the intermediate stage and not in the immediate stage. With these nuances, this proposition is revised as follows in Table 30.

Table 30: Evaluation of Proposition 7 (b)

Original proposition	*P7 (b): In the immediate stage after formalization, the efficiency of processing operations improves and negative externalities are eliminated.*
Revised proposition	*P7 (b1): In the intermediate stage after formalization, the wastage during processing reduces, leading to higher resource efficiency* *P7 (b2): In the intermediate stage after formalization, the quantity of e-waste processed per unit time reduces, leading to lower throughput* *P7 (b3): Impact of formalization on negative environmental externalities and occupation diseases, in any stage after formalization, is moderated by adherence to formalization standards*

Proposition 7 (c)

P7(c): In the intermediate stage after formalization, the firm is able to procure e-waste from new sources.

Evidence from the field (NVivo node: *P7(c)- Intermediate stage (new sources)*)

All firms, except Delta, were able to purchase e-waste from new sources i.e. sources from which they were not purchasing e-waste before becoming formal. For example, Alpha established a long-term contract with a watch manufacturer to process used watches returned by consumers. Alpha was not purchasing e-waste from this watch manufacturer, before becoming formal. Similarly, Beta was able to purchase from new bulk consumers and was also able to participate in online auctions conducted by auction firms. These online auctions were only open to formal processors (due to changes in the external environment like e-waste legislation) and firms like Beta, Gamma, and Zeta could participate and purchase e-waste. Delta could purchase e-waste immediately after they became formal through one of their previous connections (i.e. deep personal contact with previous customers). This has been described earlier. So, for the first 6 months, Delta did not have to worry about purchasing from any other source. After Delta finished processing this e-waste consignment, they started to search for new sources by participating in online auctions. A summary of evidence from various firms are given in Table 31.

Table 31: New sources of e-waste in the intermediate stage after formalization

Name	New sources of e-waste in the intermediate stage
Alpha	Purchased e-waste from new sources (bulk consumers, PCMs); Signed a long-term contract with PCM
Beta	Purchased e-waste using previous connections (bulk consumers) and from new sources (auction firms)
Gamma	Purchased e-waste using previous connections (bulk consumers) and from new sources (auction firms); Not able to sign long-term contracts with new sources (bulk consumers)
Delta	Purchased e-waste using previous connections (bulk consumers)
Zeta	Purchased e-waste from new sources (auction firms)

Evaluation: Evidence obtained from the field supports this proposition i.e. informal-turned-formal firms were able to purchase e-waste from new sources which includes bulk consumers, PCMs, and auction firms. This proposition is revised (to capture certain nuances) as follows in Table 32.

Table 32: Evaluation of Proposition 7 (c)

Original proposition	*P7 (c): In the intermediate stage after formalization, the firm is able to procure e-waste from new sources.*
Revised proposition	*P7 (c): In the intermediate stage after formalization, the firm is able to purchase e-waste from new sources (bulk consumers, PCMs, auction firms)*

Proposition 7 (d)

P7 (d): In the intermediate stage after formalization, the firm is able to get credit from banks to expand business.

Evidence from the field (NVivo node: *P7(d)- Intermediate stage (bank credit & business expansion)*)

Only Alpha and Beta had some business expansion. For example, Alpha was able to expand from a 1,000 sq. ft. facility to a 2,000 sq. ft. facility thereby increasing the workforce from 6 employees to 10 employees (#4). This was only possible due to the long-term contract with a PCM (#4). The evidence of new technology installation etc. in the intermediate stage comes from the interview with Zeta. Proprietor of Zeta mentioned that he is planning to purchase tube blasting machine soon.

Their primary source of funding were from private money lenders or family members (i.e. informal institutions) and not through any formal institutions like banks (#8). Once they became formal, they could easily get loans from private money lenders (because they had assets now) for purchasing e-waste from new sources (#17). Suppose, the firm wanted to purchase e-waste for Rs. 50 lakh from a bulk consumer, the money lender was willing to lend Rs. 25 lakh, if the firm committed to share a percentage of profit or commission to the money lender (#17). None of the firms obtained credit from banks. There are three reasons behind this. Firstly, these people did not approach banks because they knew they cannot avail loans. This is because, banks do not have the provision to lend money to those kind of people who do not have enough collateral. Secondly, e-waste processing does not have 'Industry Status' (#6, #7). The industry in which these firms operate is recycling. Though banks have provisions to lend money to small manufacturing firms, recycling does not figure in their scheme of things due to lack of Industry Status (#6, #7). If recycling is given Industry Status (i.e. recognized as an Industry by the Government), this would help to obtain financing from formal institutions (like banks) and fiscal incentives (from Government). Thirdly, all of them belong to a religion where it may be a taboo to borrow money and pay interest. For example, when asked about availing credit/loans from banks, the Business Development Manager of Epsilon responded as follows:

"See, I have studied in XYZ [one of the top-notch business schools in Asia]...I have worked in big corporates...Fortune 500 companies...I have worked in Wipro...after leaving my college, I'm little kind of religious...like, I don't go for loans, I don't believe in interest...I neither take interest or pay interest...when I bought a Harley, I paid cash...if I have cash, I do my business...because, interest is forbidden in our religion...it is not prohibited, it is banned." - (#3) [Religion- Muslims in recycling]

Evaluation: Though an overall support was found for this proposition, field evidence led to a more nuanced understanding. This proposition is revised as follows in Table 33. While developing propositions, intermediate stage was defined as 6 months after becoming formal. But, field evidence suggested a revisit to this time duration. The meaning behind intermediate stage was to capture the growth of the firm in a stage where they have moved from the starting point (i.e. immediate stage) and have not yet reached a stage where their operations/business is stabilized (i.e. final stage). Rather using 6 months, 12 months seems to be a better duration to capture the intermediate stage after formalization. This is because informal-turned-formal firms (except Delta) were not able to purchase e-waste for 1 year, after becoming formal.

Table 33: Evaluation of Proposition 7 (d)

Original proposition	*P7 (d): In the intermediate stage after formalization, the firm is able to get credit from banks to expand business.*
Revised proposition	*P7 (d1): In the intermediate stage after formalization, the firm is able to obtain credit from informal institutions to purchase e-waste from bulk consumers* *P7 (d2): In the intermediate stage after formalization, the firm is able to expand its business* *P7 (d3): Obtaining credit from formal institutions (like banks) is contingent on other factors like religious beliefs, lack of collateral, and lack of Industry Status to e-waste processing industry*

Proposition 7 (e)

P7 (e): In the final stage after formalization, the firm is able to process more variety and quantity of e-waste efficiently.

Evidence from the field (NVivo node: *P7(e)- Final stage*)

Evidence regarding e-waste variety could not be obtained. However, qualitative evidence regarding quantity and performance was obtained. The final stage for each firm (except Zeta) was considered to be the time of the fieldwork. This evidence is summarized below in Table 34.

Table 34: Quantity of e-waste and performance in the final stage after formalization

Firm	Quantity	Performance
Alpha	Low	Low
Beta	High	High
Gamma	Medium	Medium
Delta	High	High
Epsilon	Low-Medium	Low
Zeta	-	-

The representation made in the above Table is based on evidence obtained directly from firms. Low, High, and Medium categorizations are relative. Few interview quotes that illustrates these categories are listed below:

"We were having 1,000 sq. ft. yard, then it became 2,000 sq. ft. yard....6 people were working with us, then 10 people started working with us...now, it has become dull...after contract ended, all have left...now, there is no work happening in my industry...monthly, it will run twice and it remains closed in the remaining time...after this, if we had made a contract with another MNC immediately, we could have developed." – Proprietor of Alpha (#52).

"Over the last 4 years, we had total development...changes...all our statistics is going up, not coming down...year after year, our recycling capacity has gone up...only going up...we started with 40 ton in one year, in 2nd year we did 60-65 ton, after that we did 100 ton...like this, it is

going on per annum...now, it is 150 ton...it is not going down, always going up." – Management Head of Beta (#26).

Facility tours were conducted only at Beta, Gamma, Delta, and Zeta. Facilities of Alpha and Epsilon were not open due to lack of e-waste and they denied permission to conduct facility tours. Even Beta's facility remained closed, due to lack of e-waste, though permission was given for a short tour. Direct observation from these facility tours were also used to develop the low, medium, high categorization. For example, direct observation of Delta's facility corroborated the evidence that Delta is performing well (#2, #3). Delta's facility was a two storied building with two office rooms, there was closed-circuit television with 4 cameras, one covering the office and other 3 covering the shop-floor. Delta had two certifications hung on the office wall: ISO 9001, ISO 14001. The shop floor was filled with e-waste and employees were busy in processing operations. These evidence indicate that the firm is doing reasonably well.

It is interesting to observe that Consultants from STIMULUS and other stakeholders opine that all these firms are making very high profits (by processing high quantities of e-waste) and do not reveal it to outsiders (e.g., researchers, Government officials, media representatives, etc.) The rationale for making this claim are as follows:

- If they were not performing well (i.e. not making profits), they would have closed down their business. But, this has not happened. Rather, there are more informal processors who wants to become formal. For example, the SPCB has recently received applications for formalization from five informal firms.
- Proprietors of some firms have purchased land, settled in a better residential locality outside their neighborhood, and one has even purchased a farmhouse.
- Recently, STIMULUS had facilitated a training programme where informal-turned-formal firms were invited to Germany. Totally, seven Proprietors of these firms visited Germany by self-financing including expenses on visa, travel, and shopping. This included Proprietor of Delta, Business Development Manager of Epsilon, Joint Proprietor of Gamma, and four other proprietors of three informal-turned-formal firms that are not covered in my study.

Evaluation: There is mixed evidence from the field, which supports or not supports this proposition. Evidence from firms like Beta and Delta supports the proposition, but evidence from other firms do not support it. A plausible explanation for this difference could be the raw

material availability i.e. if the firm is able to purchase high quantity of e-waste regularly, there would be a higher likelihood for better performance. This pattern is evident in Table 34 and in the response obtained from these firms (#47, #34, #31). For example, Joint Proprietor of Gamma said regarding the need for regular/steady supply of e-waste:

"When there is material, there is work...when there is no material, there is no work. If there is material, we can work...what work can we do, if there is no material?" – (#31).

We could not obtain any evidence regarding variety of e-waste. This proposition is revised, by capturing more nuance from the field, in Table 35.

Table 35: Evaluation of Proposition P7 (e)

Original proposition	*P7 (e): In the final stage after formalization, the firm is able to process more variety and quantity of e-waste efficiently.*
Revised proposition	*P7 (e1): In the final stage after formalization, some firms purchase higher quantity of e-waste vis-à-vis other firms* *P7 (e2): In the final stage after formalization, some firms achieve higher performance vis-à-vis other firms* *P7 (e3): Steady supply of high quantity e-waste would lead to high firm performance in the final stage after formalization*

Proposition 7(f)

P7 (f): The outcomes in immediate, intermediate, and final stages are the same for all three methods of formalization.

Proposition 8

P8: Formalization costs will be lower and profits will be higher in the cooperative method when compared to the competitive method.

Proposition 9

P9: Formalization costs and profits for informal processors in integrative method are lower than cooperative method.

Proposition 10

P10: Profits of formal processors increases in the integrative method due to reduced collection costs.

Evaluation: These propositions could not be evaluated due to lack of appropriate data from the field. Though the existence of three methods of formalization were established through Proposition 6 (a), there was no evidence obtained from primary sources regarding competitive method and integrative method. Also, while evaluating Proposition 6, stark contrast was found between the hypothesized proposition and field evidence regarding the methods adopted by the six firms to become formal. For example, the formation of Trusts, spin-offs, joint investments, etc. emerged from the field.

Proposition 11

P11: The final profits earned by the informal-turned-formal recycler through any of the three methods (competitive, cooperative, integrative) will be higher than what it could have earned being informal.

P11.1 Economic outcome in the final stage after becoming formal

Evidence from the field (NVivo node: *P11- Profits vis-a-vis informal*)

It is to be noted that there is no evidence regarding competitive, integrative methods of formalization. This proposition is evaluated based on the evidence obtained from informal-turned-formal firms who have become formal through competitive and spin-offs method. The key question while evaluating this proposition was this: *What do informal-turned-formal firms have to say about their profits vis-à-vis what they were earning while in the informal?* A summary of this evidence can be found below in Table 36.

Table 36: Informal-turned-formal firms' profits vis-à-vis when they were informal

Firm	Profits vis-à-vis informal	Reason
Alpha	$P_{Formal} < P_{Informal}$	Higher costs; Lack of adequate e-waste quantity
Beta	$P_{Formal} < P_{Informal}$	Higher costs; Lack of adequate e-waste quantity
Gamma	$P_{Formal} < P_{Informal}$	Higher costs; Lack of adequate e-waste quantity
Delta	$P_{Formal} > P_{Informal}$	Availability of adequate e-waste quantity
Epsilon	$P_{Formal} < P_{Informal}$	Higher costs; Lack of adequate e-waste quantity
Zeta	-	-

Zeta had not yet reached the final stage, after becoming formal. Except Delta, evidence from all the other firms reveal that they are not able to make the same high profits vis-à-vis when they were informal. The fundamental reason these firms attribute to is the increased costs of running a formal e-waste processing facility and not being able to purchase adequate quantity of e-waste to run their facility. While in informal, the costs were much lower when compared to the costs being incurred in the formal. In fact, costs in the formal is almost 5 times the costs incurred in informal (#21). These costs include fixed and variable costs discussed in one of the previous propositions. Some interview quotes which best illustrate this evidence is provided below:

"Profits were higher at that time [before formalization]...now, it is less", "No...we don't get that much profits now...but, we can maintain average and keep doing business...we don't get that high profits [i.e. profits when we were in the informal]." – Management Head of Beta (#1, #6).

"Earlier, when we were getting money...we could save something. Now, when we are getting money...pay income tax, pay the industry's rent, give payment to employees, all these expenses are there...so, it is difficult to save money...very often, we also incur loss." – Proprietor of Alpha (#23).

"It was good...get material for 50,000 rupees...earn 5,000 rupees for the day...and it was enough for us...like this, we used to think. But, now...even if we earn 5 lakhs, it is not enough for us...because, the expenses are high" - Joint Proprietor of Gamma (#9).

Interestingly, some informal processors who invested to create these firms, have quit the formal firm and returned to the informal economy due to lack of profits. For example, Informal Processors A & B had invested (were a part of) in Alpha and Gamma respectively. Subsequently, they quit the formal economy (i.e. quit Alpha and Gamma) and returned to the informal economy. Only Delta claimed to have higher profits vis-à-vis informal (#18, #19). For example, Proprietor of Delta said regarding this:

"Yes...we are getting material, we are working, we are also making profits...it is not like, after making the company we sunk...it has not happened like that...I have only benefited from making the company" – (#19).

Insights while evaluating other propositions in immediate and intermediate stage are synthesized in the following Table 37. This helps to juxtapose evidence across various stages of the firm and observe interesting patterns.

Table 37: Immediate, intermediate, and final stages of informal-turned-formal firms

Firm	Revenues (immediate stage)	New sources of e-waste (intermediate stage)	Quantity (final stage)	Performance (final stage)	Profits vis-à-vis informal
Alpha	Nil. Not able to purchase e-waste.	Purchased e-waste from new sources (bulk consumers, PCMs); Signed a long-term contract with PCM	Low	Low	$P_{Formal} < P_{Informal}$
Beta	Nil. Not able to purchase e-waste.	Purchased e-waste using previous connections (bulk consumers) and from new sources (auction firms)	High	High	$P_{Formal} < P_{Informal}$
Gamma	Nil. Not able to purchase e-waste.	Purchased e-waste using previous connections (bulk consumers) and from new sources (auction firms); Not able to sign long-term contracts with new sources (bulk consumers)	Medium	Medium	$P_{Formal} < P_{Informal}$
Delta	Purchased e-waste from one bulk consumer. This covered Delta for 6-7 months.	Purchased e-waste using previous connections (bulk consumers)	High	High	$P_{Formal} > P_{Informal}$
Epsilon	-no evidence-	-no evidence-	Low-Medium	Low	$P_{Formal} < P_{Informal}$
Zeta	Nil. Purchased e-waste from one bulk consumer. Waiting to purchase more e-waste to start processing.	Purchased e-waste from new sources (auction firms)	-	-	-

It is interesting to find that Beta is not able to make profits vis-à-vis informal though Beta is able to purchase more quantity of e-waste and able to achieve good performance. While evaluating an earlier proposition, it was found that Delta used its previous connections to purchase high quantities of e-waste from a bulk consumer (telecom sector), immediately after formalization. This evidence could be a plausible reason why Delta did not face difficulties like other firms. Another plausible reason could be the degree of effort exerted by each firm in sales & marketing. Though evidence regarding this is weak, it is noteworthy to consider this reason. For example, evidence from the Proprietor of Delta reveals that unlike other firms, Delta exerts more effort in sales & marketing to search for potential bulk consumers and establish contact with their purchase/disposal officers. In summary, what emerges is the presence of several moderating variables (increased costs of running a formal firm, lack of appropriate quantity of e-waste, level of sales & marketing efforts) which impacts profits vis-à-vis informal.

P11.2 Non-economic outcomes in the final stage after becoming formal

There were some interesting non-economic outcomes (i.e. outcomes that are not related to profits and other monetary concepts) that emerged from field evidence. These were not hypothesized while developing this proposition. These non-economic outcomes are higher social status, spill-over benefits, and higher levels of stress. These outcomes are described below.

Higher social status: There is evidence of higher social status after becoming formal i.e. recognition in society, sense of achievement, and having a name. To understand the importance of this concept, one also needs to understand where they came from. They came from the streets (i.e. informal way of e-waste processing) to office suites (i.e. formal firms). Now (after becoming formal), people from STIMULUS, Government, and research scholars from reputed universities approach them for understanding e-waste processing. The Proprietors of these firms are invited to attend training programmes and conferences in India and abroad. Recently, they were invited to visit Germany for a workshop on e-waste processing. Some of them were even approached by political parties to help them get votes. Before becoming formal, children of the firms' proprietors attended the Government Urdu School in their neighborhood. But, now these children attend private English Medium Schools. After becoming formal, the children proudly say to their teacher that their father is an industrialist. These are evident from comments #1, #3, #5, #6, #7, #16, #17.

Spill-over benefits: Employees of these informal-turned-formal firms are also benefitted. Earlier, they were not employees and dependent on daily wages. Now, they have fixed salary, timings, and other employee benefits. These are evident from comments #10, #11.

Higher levels of stress: While working in the informal economy, they were working peacefully without much tension. They worked for less than two weeks (sometimes only 5 days) in a month and spent the rest of the time for leisure. But, after becoming formal, they have lost this peace of mind. Now, they do not have time for leisure because they are on the constant search to get appropriate quantity of e-waste to generate sufficient revenues. This evidence of higher levels of stress and loss of peace/happiness, was revealed by proprietors of Alpha, Gamma, Delta, and Consultants from STIMULUS. For example, Consultant X said regarding her interaction with the Proprietor of Beta:

"Before formalization he used to say: 'We get 2000 rupees per day and we work for 5 days or so a month. That is enough for us. Why do we need more money?' But, after formalization he says: 'from where can I get more e-waste? I need to run my plant at full capacity. I need to feed my 10 employees. We need to run the plant everyday'. This is a stark difference I have noticed in him. This difference is due to the formalization of his business. In fact, his happiness index would have come down due to formalization." – (#20).

Evaluation: Evidence of the presence of moderating variables was found (vide P11.1) that enriched the existing proposition on economic outcomes. Moreover, interesting evidence regarding non-economic outcome emerged from the field (vide P11.2) that added additional dimension in our understanding of this formalization phenomenon. In the light of these evidence, this proposition is revised as follows.

Table 38: Evaluation of Proposition 11

Original proposition	*P11: The final profits earned by the informal-turned-formal recycler through any of the three methods (competitive, cooperative, integrative) will be higher than what it could have earned being informal.*
Revised proposition	*P11 (a): In the final stage, profits earned by the informal-turned-formal firm is not necessarily higher than what it could have earned being informal.* *P11 (b) Some Joint Proprietors of informal-turned-formal firms have quit and returned to work in the informal economy due to lack of profits in the final stage.* *P11 (c): In the final stage, profits vis-à-vis informal is moderated by costs of running the formal firm, quantity of e-waste, sales & marketing efforts.* *P11 (d): In the final stage, non-economic outcomes (higher social status, spill-over benefits, higher levels of stress) also exist*

Proposition 12

P12: The observed outcomes of informal-turned-formal processors are only due to formalization.

P12.1 Changes not related to formalization

Evidence from the field (NVivo node: *P12- Non-formalization related changes*)

Only Delta had installed a machine that was not related to formalization procedures. They had fabricated a machinery to automate a manual part of metal recovery process. This need to automate came due to increasing volume of e-waste which was difficult to handle manually (#3, #4). Beta and Gamma only have plans to install new machinery (not mandated for formalization) for e-waste processing (#1, #6, #2). For example, Gamma has ordered for a machine to automatically peel-off metal from the plastic coating of copper and aluminum wires (#2). Thus, only Delta had implemented a new practice by installing a machinery. This could have plausibly increased productivity (i.e. higher quantity of e-waste processed per unit time) and thus explain the higher performance of Delta.

P12.2 Influence of E-waste Rules on formalization

Evidence from the field (NVivo node: *P12- Influence of E-waste Rules 2011*)

Field evidence revealed that many bulk consumers comply with EMHR and dispose e-waste only to formal processors. But, there are also many bulk consumers who do not comply with EMHR and dispose e-waste to informal processors. Thus, EMHR can be posited to have a mixed effect on the outcomes of informal-turned-formal firms. Some firms have been able to purchase e-waste from bulk consumers, only because they (bulk consumers) wanted to comply with EMHR. For example, Proprietor of the high performance firm Delta attributed his success to EMHR due to which Delta was able to purchase high quantities of e-waste. As per EMHR, Central Government organizations could only dispose e-waste to formal processors through MSTC online auctions. Without the license/certificate from the Government, a processor was not able to participate in these auctions. This has helped many informal-turned-formal processors to participate in such auctions and purchase e-waste through bidding.

An interesting finding emerged from the field regarding EMHR and formalization. All the informal-turned-formal firms full under MSMEs because their investments (in plant & machinery) are less than Rs. 25 lakhs. MSMEs are exempt from complying with EMHR, as per the legislation. Ideally, these firms need not go through the formalization process to get the e-waste license/certificate. But, if they do not have the license/certificate, many bulk consumers do not prefer to dispose e-waste to them. During conversations with informal-turned-formal firms, it was evident that they were not aware of this clause in EMHR.

P12.3 Influence of external market conditions on formalization - Role of technological change

Evidence from the field (NVivo node: *P12- Technological change*)

Technological change occurring in the electrical & electronics industry impact the profits of informal-turned-formal firms. The types of technological change and its impact are revealed below.

Reduction in metal content: The content of metals used in e-products have reduced over time. The e-waste processors used to recover these metals and sell in the marketplace. Due to reduction in metal content, the amount of metals recovered is less and consequently lowers the revenues. The metal content has reduced, over time, for all types of printed circuit boards used in various e-products. Business Development Manager of Epsilon said that earlier they could purchase boards for Rs. 800 per kg and make decent profits of above Rs. 150 per kg by incurring Rs. 650 per kg as processing costs. Due to reduction in metal content, these boards can only be purchased at Rs. 600 per kg. Since the processing costs remain the same at Rs. 650 per kg, their profits have reduced. In some cases, the processing costs is higher than the value of metal that can be recovered. These are evident from comments #1, #2, #10, #23, #29, #30. For example, Proprietor of Delta said regarding the declining metal content from printed circuit boards:

"If you go back to 10 years....when we used to recover gold from the boards that you just now saw [he had shown the PCBs]...we used to get 2 grams of gold from one board...but, now we cannot get even 200 grams from 1 kg board." – (#27).

Substitution of materials with low recyclability: Low-cost materials with better properties are being substituted for high-cost materials. For example, laptop manufacturers initially made the casing with plastic. This plastic casing could be disassembled and sold to plastic granule manufacturers. But, these days laptop manufacturers use Bakelite instead of plastic due to better thermal resistance, low conductivity, and low cost. Laptop casing made of Bakelite does not *create a market* because it cannot be sold to plastic granule manufacturers. Bakelite can only be incinerated at temperatures above 1000 degree Celsius. This material substitution has lowered the revenues for informal-turned-formal processors. These are evident from comments #3, #4, #24, #25, #26.

Miniaturization: Miniaturization has reduced the weight (volume) of products which has reduced the recovery value due to size reduction. These are evident from comments #5, #6, #9, #18, #21. For example, the proprietor of Delta mentioned:

"Earlier, the CPU used to be bigger...now, it has become very small...and recovery becomes less, due to this." – (#21).

Product design/evolution of products: The evolution from CRT to LCD and to TFT, from separate CPUs to in-built CPUs, etc. also negatively impacts the profits of informal-turned-formal e-waste processors. These are evident from comments #5, #11, #13. For example, Proprietor of Gamma said:

"CRT gets sold in second-hand market...LCD does not get sold as second-hand...if even CRT becomes scrap, it still gets sold in second-hand market...but, LCD does not get sold if it becomes scrap." – (#13).

Though these technological changes have reduced the amount of money that can be made from e-products (#1, #12, #13, #15, #17, #19, #21, #26), the overall quantity of e-products have shown an increasing trend due to increasing population, electronics-savvy consumers (#22). Theoretically speaking, if this decrease in recovery value is offset by the increase in quantity, e-waste processors can still earn profits (at an industry level and not at a firm level).

P12.4 Influence of external market conditions on formalization? Role of competition

These informal-turned-formal processors compete among themselves (perhaps in a healthy manner) and also with the big formal processors to purchase e-waste. The big formal processors are the multinational e-waste processing companies operating in India and Indian e-waste processors. These big formal processors have high investments, large facilities, and sophisticated salesmen who speak English and wear executive dress. Thus, these big formal processors have an impressive face value when compared to the informal-turned-formal processors. Many bulk consumers dispose their e-waste to these big formal processors due to this impressive face value without considering the actual processing being done in these facilities. The informal-turned-formal processors are educated only up to high school level and somehow they are perceived as not doing their work properly (in the formal way) when compared to the English speaking big formal processors. Apart from this perceived value, there is one more reason why this competition negatively impacts the profits of informal-turned-formal processors. The number of formal e-waste processors have increased over time. In 2005, there were hardly 2 formal e-waste processors in India. But, in 2014 there were 43 formal e-waste processors in Karnataka alone. When bulk consumers and PCMs dispose e-waste through auctions, the price increases due to competition among processors. This increases the purchase price of e-waste for informal-turned-formal processors and big formal processors. These are evident from comments #1, #2, #10, #12, #14, #25, #35, #39. This is also corroborated by evidence from secondary sources (#44, #45, #22, #46). For example, one evidence narrates the intensity of competition present in this industry. A formal processor's competitor posed as a journalist to get information about this processor's customers (i.e. bulk consumers, PCMs). Later, the competitor poached these customers and were able to purchase e-waste from them.

Evaluation: No evidence was found to support this proposition. Field evidence suggests that observed outcomes of informal-turned-formal processors are not due to formalization alone. Other external factors also shape the outcomes of formalization. For example, High competition from e-waste processors that leads to higher purchase price for e-waste or difficulty to purchase e-waste; technological change leading to reduction in recovery value; low compliance to EMHR has negatively influenced the profits that can be made by informal-turned-formal processors. On the other hand, compliance to E-waste Rules has also helped them to purchase e-waste from bulk consumers, which they would not have got without showing the license. To capture these nuances, this proposition is revised as follows in Table 39.

Table 39: Evaluation of Proposition 12

Original proposition	*P12: The observed outcomes of informal-turned-formal processors are only due to formalization.*
Revised proposition	*P12 (a): The outcomes (in immediate, intermediate, and final stages) of informal-turned-formal processors are not only due to formalization* *P12 (b): The outcomes are moderated by Bulk Consumers' compliance with EMHR and external environment (technological change, competition)*

Emergent Themes

Apart from using evidence to evaluate these propositions, more evidence emerged from the field (inductive) that enriched the conceptual framework. These evidence are conceptualized under appropriate themes and summarized below.

Theme 1: Challenges faced by informal-turned-formal firms during and after formalization

Alpha, Beta, Gamma, Delta, Epsilon, and Zeta faced several challenges during and after formalization. These challenges are summarized in Table 40. The major operational challenge for these firms, after they become formal, is not being able to ensure steady supply of high quality (i.e. maximum economic value can be obtained) and quantity of e-waste to meet their increased capacity and costs.

Table 40: Challenges faced by informal-turned-formal firms

During formalization	After becoming formal
Time delay between applying for formalization and getting the license/certificate. Money is locked during this time delay. Cannot purchase e-waste. Have to work in the informal economy during this delay.	Not able to purchase "enough" material to meet capacity due to competition from big formal processors, higher purchase prices, low compliance of bulk consumers & PCMs with EMHR, MNC bulk consumers raising their standards. Not able to sign long-term contracts with bulk consumers, PCMs due to competition from big formal processors
Social pressure due to fear of knowledge spill-over • This was experienced only by Alpha and Beta because they were the first-movers.	Higher costs of doing business
Government related: • Officers have a say to decide the facility layout • Ad-hoc frequently changing rules. Ex: payment for Rs. 1 lakh security deposit was mandated from 2012. But, there are plans to cancel this Rule. • Bureaucratic process i.e. complex administrative process and paper work. Also includes pleasing officers, befriending, and bribing them.	Government related: • License/certificate given to the building. If relocating the facility, need to re-start the formalization process. • Ad-hoc rules. Ex: informal-turned-formal firms while renewing their license need to take a bigger land and re-apply for formalization, need to own the land (i.e. purchase and not rent/lease) or show bank transactions worth Rs. 1 crore, banning disassembly within city limits. • Time delay in license renewal: not able to purchase e-waste during this delay while costs need to be incurred

Interviews with stakeholders, apart from informal-turned-formal firms, revealed conflicting perspectives regarding these operational challenges. MNC bulk consumers are large IT, Hi-Tech firms operating in multiple offices across the globe. *The big formal processors and small informal-turned-formal processors compete for purchasing e-waste from such MNC bulk*

consumers. In fact, many informal firms have become formal with the ambition to purchase e-waste from MNC bulk consumers. But, due to intense competition from the big formal processors, they are not able to sign long-term agreements or purchase e-waste with these bulk consumers. Another reason is the higher standards set by these MNC bulk consumers. For example, bulk consumers like Bosch, General Electricals, etc. dispose e-waste only to those e-waste processors who have large facilities, a minimum percentage of women employees, canteen facilities, other employee welfare schemes like health insurance, certification from external agencies (like ISO, OSHA, R2), etc. For example, many US-based bulk consumers prefer to dispose e-waste to formal processors who have R2 certification (this is a certificate for responsible recycling, given by US based organization). Typically, informal-turned-formal firms do not match with these standards, though they have become formal. This is why firms like Delta had gone for ISO certifications and Beta had implemented employee welfare schemes. *Many informal-turned-formal firms do not have the financial capital to invest in bigger facilities or to get certifications from external agencies*. They became aware of these difficulties only after becoming formal. During formalization, these higher standard being set by MNC bulk consumers were not known to them. Consultants from STIMULUS opine that the informal-turned-formal firms should purchase e-waste from small bulk consumers like banks, hospitals, post-offices, manufacturing firms in the industrial areas, etc., rather than competing with the big formal processors to purchase e-waste from MNC bulk consumers. But, there is a reason why informal-turned-formal firms are always investing efforts to purchase e-waste from MNC bulk consumers. Only from such sources, good quality and quantity of e-waste are available in a single transaction. Small bulk consumers like banks would only be able to dispose 20 computers (which would be nearing its end-of-life) when compared to a lot of 500 computers (which would have been used only for 2 years) disposed by MNC bulk consumers . Thus, there is potential to generate higher profits from MNC bulk consumers' e-waste. *The fundamental aim for any formal processor is to secure a steady supply of good quality and quantity of e-waste from at least one MNC bulk consumer*. This fundamental aim emerged during interviews with informal-turned-formal processors and big formal processors. For example, Business Development Manager of a formal processor said:

"Focusing on IT waste is better to get started with doing the business…quantity is good, quality is also good…make tie-ups / agreements with some 2-3 MNCs, and IT waste will keep coming to you…later on, one can venture into other sources of e-waste. The earlier firm where I was working, we had an agreement with AAA [a large telecom firm]…so all the scrap from towers

etc. we used to get regularly. With that single firm as our customer, we were able to make profits" – (#39) [Any info. for formalization chapter].

Based on these evidence, key challenges faced by informal-turned-formal firms are summarized below:

- Significant time delays in approving and renewing licenses leads to financial stress due to the inability to purchase e-waste
- Inability to ensure steady supply of good quality, quantity of e-waste lowers their ability to generate revenues higher than the costs
- Ad-hoc, frequently changing rules by SPCB increases their costs of doing business

Theme 2: Presence of contingent characteristics

Embeddedness: In this formalization phenomenon, economic activities (ex: purchasing e-waste, competing with other e-waste processors, etc.) were found to be "embedded" in kinship and social ties. This concept of embeddedness within economic activities was developed by Granovetter (1985). Evidence from the field led to the presence of this concept. All the informal-turned-formal firms belong to a single religion (Muslim) and share the same dialect. Mentioning of this religion emerged during interviews with several stakeholders including Proprietors of informal-turned-formal firms, Informal Processors, Consultants from STIMULUS, Formal Processors, and Machinery Manufacturers. For example, Proprietor of Zeta said that religion also matters to purchase e-waste. Most purchase/disposal officers at MNC bulk consumers do not belong to this religion and prefer to dispose e-waste to formal processors of their religion. Proprietors of these informal-turned-formal firms have a strong ties with their community. They want all informal-turned-formal processors and informal processors to prosper as they care for each other's livelihoods. For example, Joint Proprietor of Gamma said that though he is personally aware of informal processing happening in his neighborhood, he will not care to complain about them to Government. Rather, he requests them to do their processing in closed-doors outside the public view. Proprietors of these informal-turned-formal firms do not believe in cut-throat competition by taking away the business of other informal-turned-formal firms. Sometimes, they jointly invest money to purchase e-waste from a bulk consumer and share the profits. Sometimes, they even collude while bidding for e-waste during auctions. Such coordination do not happen among big formal

processors. Another interesting evidence was regarding kinship. The informal processors in this neighborhood (where formalization was initiated) have been involved in scrap recycling for generations. Their ancestral origins is connected to Kolar Gold Fields. Their second and third generation grandparents lived in Kolar Gold Fields, where they extracted gold from the mill tailings using acid leaching. Later, this stream of business dwindled and they started looking out for other options. They ventured into metal recovery from gold coated watches, then from telecom products, and when electronic products started entering the waste stream, they realized that metals like gold can be extracted from such products too. This knowledge resides within the family and are not revealed to outsiders. For example, Beta, Delta, and Zeta belonged to this family and naturally they also do metal recovery. However, it is to be noted that there are also exceptions. For example, Proprietor of Alpha did not have any ancestral origins in scrap recycling. Proprietor of Alpha learnt this business by interning with an informal processor (who does disassembly) in the neighborhood. After spending 6 months as an intern, he started his own e-waste disassembly business. Apart from the ancestral origins (i.e. generational bonds), there are other ties like siblings, cousins, in-laws, etc. Many informal processors in the neighborhood have such relations with each other. These ties do not end within their neighborhoods and extend further within India and even to countries outside India from whom they purchase e-waste (sometimes illegally). For example, an informal-turned-formal processor in Pune was related (in-law ties) to the family of Proprietor of Alpha. They also do e-waste related business together.

Minimalist way of life: Generally, the informal processors (including some of them who have become formal) are easy going individuals, who do not meticulously plan their life (i.e. no high ambitions), have a circular concept of time (ex: they generally arrive 2-3 hours late for any important meeting), live life at the moment, and enjoys leisure (watching television and spending time with family and friends). They were economically well-off even when they were working in the informal economy. The mentality of informal processors is to work for few days a month (say, 5 or 10) and then relax during other days of the month. Even if they could earn a minimum profit of Rs. 5,000 per day in the informal economy, they did not want to work during the entire month only to earn more money. Rather, they used to work for 5 days (sometimes even less) or 10 days a month, earn enough money (just enough money) to meet their basic needs, and rest of the month was spent on leisure. Consultant X deeply philosophized regarding the priorities they set in their life (before becoming formal):

"*The priorities…they have one set priority and they are happy. Finally, what are you living for? You need to be happy…after studying all this, after working, slogging like this, if you ask me…if you compare me with one informal sector, they are much more happy. So, I really don't know…can I go back to their state? I can't go. It's like that. So, this is one social thing which I have learnt from them…I don't have an answer…it's something very very amazing."* – (#10) [Any info. for formalization chapter].

This minimalist way of living would have an influence when they become formal. Respondents from all the informal-turned-formal firms were citing higher levels of tension in life, after they become formal. This was also discussed while evaluating Proposition 11.

Educational background: Though they are knowledgable about e-waste processing, they lack formal school education (some of them are even illiterates). So, they have inhibition to approach educated people and talk to them. This negatively influences their sales and marketing efforts and their ability to purchase e-waste from MNC bulk consumers.

These contingent characteristics (embeddedness, minimalist way of life, educational background) can be grouped as a moderating factor that would influence the formalization process and its outcomes in immediate, intermediate, and final stages.

Theme 3: Business Model before and after formalization

Three important factors were evaluated to understand the business model before and after formalization (these factors are summarized in Table 41 and Table 42):

- Characteristics of e-waste supply (i.e. sources, type, quantity, frequency)
- Nature of e-waste processing operations
- Buyers of processed e-waste

Table 41: Characteristics of e-waste supply

Firm	Formal	Characteristics of e-waste supply			
		Sources	Type	Quantity	Frequency
Alpha	Before	Bulk consumers, PCMs	Telecom (2%), Computers & Peripherals (70%), Electrical panels/drives (10%)	500 MT per annum	Once or twice per month
	After	-	-	Zero	Zero
Beta	Before	Bulk consumers, PCMs	Telecom (30%), Computers & Peripherals (25%), Electrical panels/drives (15%)	High	Ad-hoc, Monthly once
	After	Bulk consumers, PCMs	No change	No change	Ad-hoc
Gamma	Before	Bulk consumers, PCMs, Auction firms	Telecom (2%), Computers & Peripherals (70%), Electrical panels/drives (10%)	1MT-10MT in a single deal	Daily, Monthly twice, 15 days/month
	After	Auction firms	No change	500kg-5MT in a single deal	Ad-hoc
Delta	Before	Scrap traders	Telecom (35%), Computers & Peripherals (25%), Electrical panels/drives (15%)	Enough (met the capacity)	Ad-hoc
	After	Bulk consumers, PCMs, Auction firms	No change	Not enough to meet increased capacity	Ad-hoc
Zeta	Before	Bulk consumers, PCMs, Formal processors	Telecom (2%), Computers & Peripherals (70%), Electrical panels/drives (10%)	15-20 MT per month	Ad-hoc, 5 to 6 times a month
	After	Bulk consumers, PCMs, Auction firms	No change	-	-

Table 42: Nature of e-waste processing operations & buyers of processed e-waste

Firm	Formal	Nature of e-waste processing operations	Buyers of processed e-waste
Alpha	Before	Direct reuse, repair-cum-refurbish, cannibalize, disassemble into commodities	Dealers in second-hand market, commodity recyclers
	After	-Same as above-	Dealers in second-hand market, commodity recyclers, non-recyclable waste given to TSDF
Beta	Before	Direct reuse, repair-cum-refurbish, cannibalize, disassemble into commodities, metal recovery	Dealers in second-hand market, commodity recyclers,
	After	-Same as above-	Dealers in second-hand market, commodity recyclers, non-recyclable waste given to TSDF
Gamma	Before	Direct reuse, repair-cum-refurbish, cannibalize, disassemble into commodities	Dealers in second-hand market, commodity recyclers, PCBs sold to informal processors in Delhi
	After	-Same as above-	Dealers in second-hand market, commodity recyclers, PCBs sold to formal e-waste processor, non-recyclable waste given to TSDF
Delta	Before	Direct reuse, repair-cum-refurbish, cannibalize, disassemble into commodities, metal recovery	Dealers in second-hand market, commodity recyclers,
	After	-Same as above-	Dealers in second-hand market, commodity recyclers, non-recyclable waste given to TSDF
Zeta	Before	Direct reuse, repair-cum-refurbish, cannibalize, disassemble into commodities, metal recovery	Dealers in second-hand market, commodity recyclers,
	After	-Same as above-	Dealers in second-hand market, commodity recyclers, PCBs sold to formal e-waste processor, non-recyclable waste given to TSDF

Though direct reuse, repair-cum-refurbish, cannibalization are being done, many firms claim that they do not do these operations. Sometimes, instead of engaging in these operations, they would sell the collected e-waste to dealers in second-hand market i.e. they would sell to dealers who can sell in second-hand market through direct reuse, repair-cum-refurbish, and cannibalization (the processing operations of processors are explained in Chapter 5). *One common operation being done at all these informal-turned-formal firms is disassembling into commodities and selling them to commodity recyclers.* The commodity recyclers include specialized scrap metal traders or scrap metal smelters. After becoming formal, these informal-turned-formal firms are mandated to sell to those scrap commodity recyclers who can give a bill and transact through banks (ex: using demand drafts). The commodity recyclers are such that they will purchase from informal and formal e-waste processors. When they purchase from formal firms, they transact using bills and bank accounts (which is legal). When they purchase from informal processors, they transact using cash (which is illegal). *The key finding here is formalization has not changed the business model (i.e. from where to purchase, types of e-waste purchased, what processing operations to be done, whom to sell, etc.)*. Rather, formalization has imposed certain restrictions in this business model i.e. transact only using bills and through bank accounts so that tax can be deducted, pollution abatement technology is installed so that pollution is reduced, etc. Apart from this, processing operations have remained the same before and after formalization. In two cases (i.e. Zeta and Gamma), it was revealed that after becoming formal they sell PCBs to formal e-waste processors (vide Table 42). But, they always have an option to sell those PCBs to informal processors in Delhi or Bangalore who does metal recovery from PCBs. Sometimes, Zeta opts for this option based on who pays the highest for PCBs.

Towards a suggestive model for understanding formalization

Based on the evaluation of these 12 propositions and emergent patterns (i.e. Theme 1, Theme 2, and Theme 3), the initial conceptual framework is refined to provide a suggestive model for understanding formalization process. A list of revised propositions and emergent themes are summarized in Table 43. The refined conceptual framework to understand formalization is illustrated in Figure 15.

Table 43: Summary of revised propositions

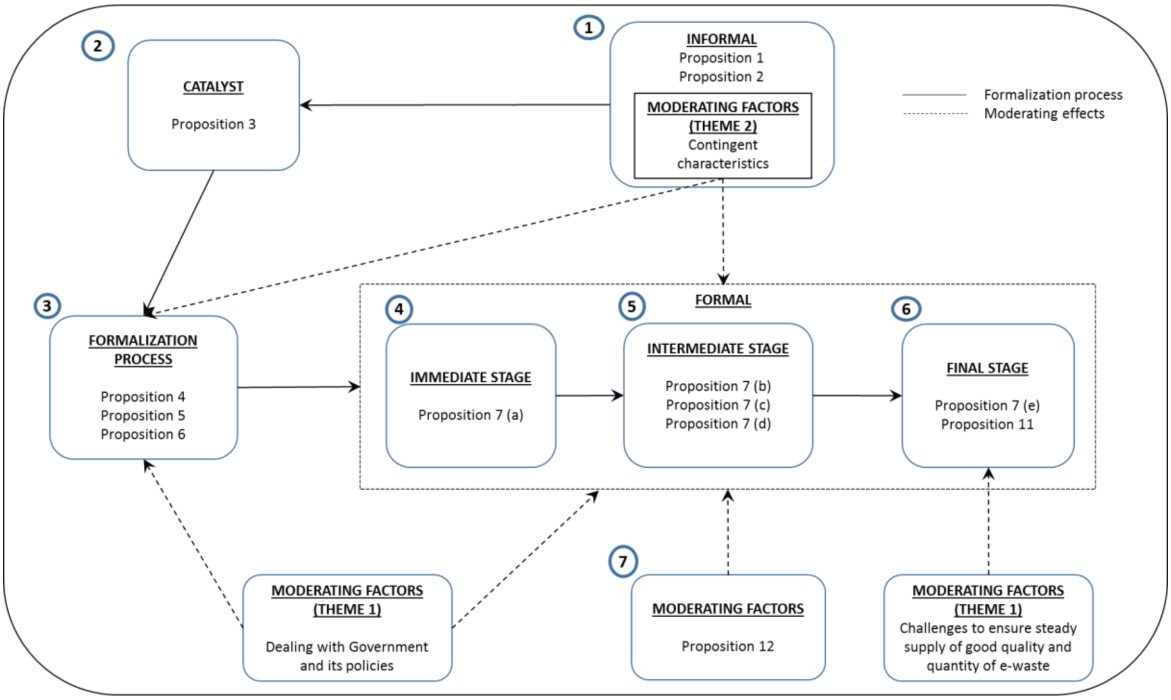
No.	Original Proposition	No.	Revised Proposition
1	Informal processors process e-waste without any pollution abatement technology, protective equipment and make profits.	1 a)	Informal processors process e-waste without any pollution abatement technology, protective equipment, and make profits
		b)	Pollution abatement technology is not used during and after e-waste processing
		c)	Informal e-waste processing leads to occupational diseases and negative environmental externalities
2	Informal processors do not formalise because they perceive formalisation to involve higher processing costs and consequently reduced profits.	2 a)	In the early stage of this industry, the terms informal and formal did not exist
		b)	Informal processors, in the early stage of this industry, did not formalize because such concepts did not even exist and it was their “way of living”
		c)	Informal processors, in the later stage of this industry, did not formalize because they perceive formalization to involve higher processing costs and consequently reduced profits.
3	External intervention motivates informal processors to formalise by showing the potential for more profits after formalisation.	3 a)	External intervention occurred and initiated formalization
		b)	Informal processors were motivated to formalize due to two reasons: - Reluctantly formalized due to changes in the external environment - Expecting incentives from Government
4	Formalisation of informal processors is done using external help.	4 a)	Formalization of informal processors is done using external help.
		b)	Nature of external help is non-monetary and facilitative which continues even after formalization.
		c)	Degree of external help was very high for the first two informal-turned-formal firms when compared to other firms.
5 a)	Formalisation process involves installing prescribed technology or equipment for processing e-waste and obtaining registration from the respective SPCB.	5 a1)	Obtaining authorization from the respective SPCB is a 8-step process which also includes installing appropriate pollution abatement technology.
		a2)	There are no technology standards for pollution abatement technology, prescribed by the Government.
		a3)	Appropriate pollution abatement technology is dependent on whether the firm does disassembly or metal recovery or both.
		a4)	Capacity planning is ad-hoc and jointly decided by the firm and SPCB

5 b)	Formalisation is supposed to eliminate negative externalities during e-waste processing.	5 b1)	Formalization is theoretically supposed to minimize occupational diseases and negative environmental externalities during and after e-waste processing.
		b2)	This is assuming firms' adherence with formalization standards.
6 a)	There are three methods to formalise: competitive, cooperative, and integrative.	6 a)	There are three methods to formalize: competitive, cooperative, and integrative.
b)	Informal processors choose competitive method if economic value, quantity, and frequency of e-waste supply is high.	b)	Informal processors formalize using a hybrid method that is simultaneously cooperative, competitive, and involves spin-offs.
c)	Informal processors choose cooperative method if economic value, quantity, and frequency of e-waste supply is low.		-Could not be evaluated -
d)	Informal processors choose integrative method if economic value is low but quantity and frequency of e-waste supply is high.		-Could not be evaluated -
7 a)	In the immediate stage after formalisation, cost of doing business increases and this decreases profits.	7 a1)	In the immediate stage after formalization, costs of doing business (fixed and variable) increases
		a2)	In the immediate stage after formalization, revenues are zero due to lack of e-waste purchased (under stable external environment)
b)	In the immediate stage after formalisation, the efficiency of processing operations improves and negative externalities are eliminated.	7 b1)	In the intermediate stage after formalization, the wastage during processing reduces, leading to higher resource efficiency
		b2)	In the intermediate stage after formalization, the quantity of e-waste processed per unit time reduces, leading to lower throughput
		b3)	Impact of formalization on negative environmental externalities and occupation diseases, in any stage after formalization, is moderated by adherence to formalization standards
c)	In the intermediate stage after formalisation, the firm is able to procure more e-waste from new sources.	7 c)	In the intermediate stage after formalization, the firm is able to purchase e-waste from new sources (bulk consumers, PCMs, auction firms)
d)	In the intermediate stage after formalisation, the firm is able to get credit from banks to expand business.	7 d1)	In the intermediate stage after formalization, the firm is able to obtain credit from informal institutions to purchase e-waste from bulk consumers
		d2)	In the intermediate stage after formalization, the firm is able to expand its business
		d3)	Obtaining credit from formal institutions (like banks) is contingent on other factors like religious beliefs, lack of collateral, and lack of Industry Status to e-waste processing industry
e)	In the final stage, the firm is able to process more variety and quantity of e-waste efficiently.	7 e1)	In the final stage after formalization, some firms purchase higher quantity of e-waste vis-à-vis other firms

		e2)	In the final stage after formalization, some firms achieve higher performance vis-à-vis other firms
		e3)	Steady supply of high quantity e-waste would lead to high firm performance in the final stage after formalization
f)	The outcomes in immediate, intermediate, and final stages are the same for all three methods of formalisation.		-Could not be evaluated -
8	Formalisation costs will be lower and profits will be higher in the cooperative method when compared to the competitive method.		-Could not be evaluated -
9	Formalisation costs and profits for informal processors in integrative method are lower than cooperative method.		-Could not be evaluated -
10	Profits of formal processors increases in the integrative method due to reduced collection costs.		-Could not be evaluated -
11	The final profits earned by the informal-turned-formal recycler through any of the three methods (competitive, cooperative, integrative) will be higher than what it could have earned being informal.	11 a)	In the final stage, profits earned by the informal-turned-formal firm is not necessarily higher than what it could have earned being informal.
		b)	Some Joint Proprietors of informal-turned-formal firms have quit and returned to work in the informal economy due to lack of profits in the final stage.
		c)	In the final stage, profits vis-à-vis informal is moderated by costs of running the formal firm, quantity of e-waste, sales & marketing efforts.
		d)	In the final stage, non-economic outcomes (higher social status, spill-over benefits, higher levels of stress) also exist
12	The observed outcomes of informal-turned-formal recyclers are only due to formalisation.	12 a)	The outcomes (in immediate, intermediate, and final stages) of informal-turned-formal processors are not only due to formalization
		b)	The outcomes are moderated by Bulk Consumers' compliance with EMHR and external environment (technological change, competition)
		Theme 1	Challenges faced by informal-turned-formal firms during and after formalization - Significant time delays in approving and renewing licenses leads to financial stress due to the inability to purchase e-waste - Unable to ensure steady supply of good quality, quantity of e-waste lowers their ability to generate revenues higher than the costs - Ad-hoc frequently changing rules by SPCB increases their costs of doing business

		Theme 2	Presence of contingent characteristics: - Embeddedness - Minimalist way of life - Educational background
		Theme 3	Formalization has not changed the business model of informal-turned-formal firms

Figure 15: Revised conceptual framework to understand formalization



This study contributes to the understanding of formalization process by developing a conceptual framework that is grounded on field evidence. This conceptual framework can be enriched by studying and carefully documenting more cases of informal-turned-formal firms in e-waste processing and other post-consumer waste (ex: lead-acid batteries, end-of-life vehicles, biomedical, etc.) processing contexts.

Key findings of this study

Key findings of this study on formalization process are summarized below:

a) Merely formalizing the informal processors does not reduce environmental externalities and occupational diseases. This reduction depends on voluntary adherence to formalization standards (vide Proposition 7(b3)).

b) The simplistic assumption that formalization would help informal processors to process more e-waste efficiently due to scale economies is falsified through this field study. This is due to higher costs and lower revenues (vide Propositions 7, 11, and Theme 1). Formalization has not changed the fundamental business model of informal-turned-formal processors (vide Theme 3).

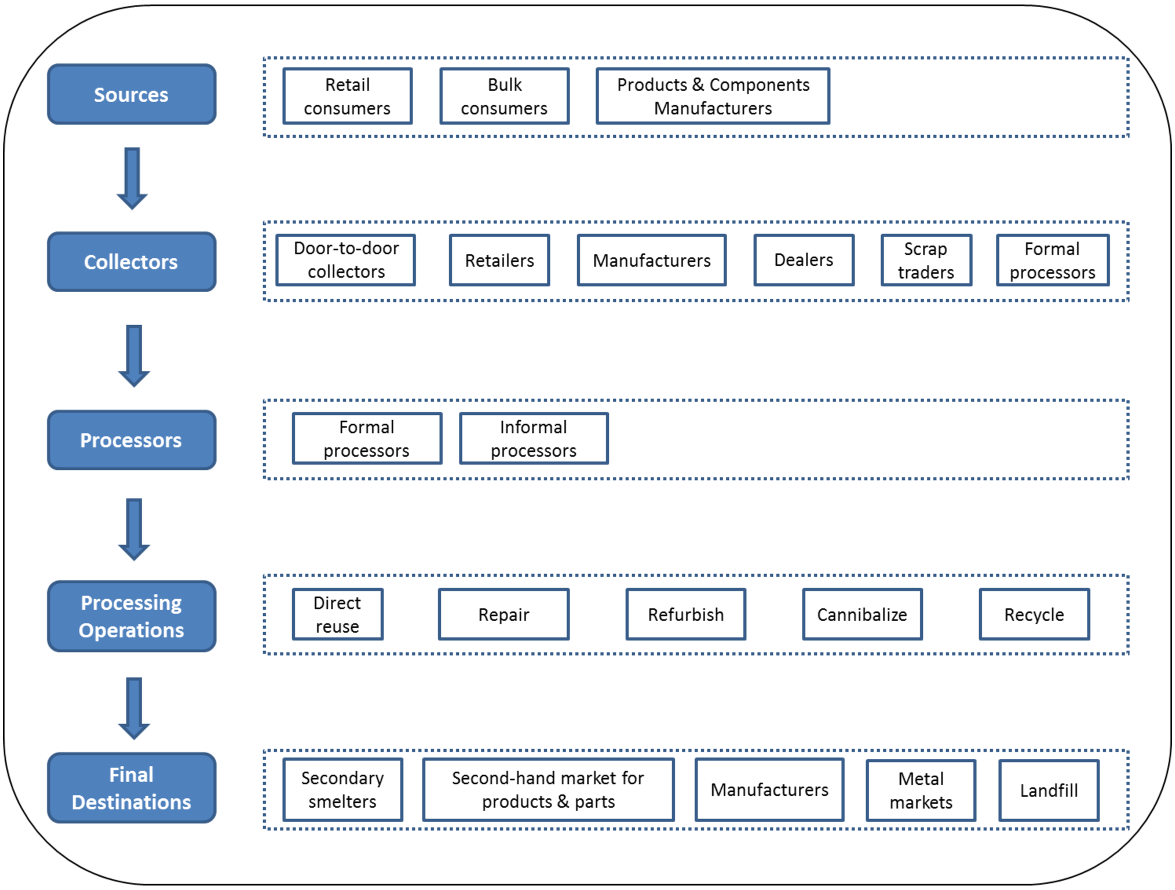
c) Some Joint Proprietors of informal-turned-formal firms have quit and returned to work in the informal economy due to lack of profits in the final stage. For example, Informal Processor A was initially a part of Alpha; Informal Processor B was initially a part of Gamma.

d) It is important to recognize the contingent characteristics (ex: embeddedness, minimalist way of life) of informal processors in this discussion/debate on formalization

Chapter 5: Understanding e-waste RSC

A conceptual framework for e-waste RSC was hypothesized in Chapter 3. The purpose of this chapter is to evaluate propositions (developed as part of this conceptual framework) and discuss emergent themes to understand the e-waste RSC. To help improve continuity, the hypothesized conceptual framework is reproduced below.

Conceptual framework of e-waste RSC



Proposition 1

P1: Sources of e-waste are Retail Consumers, Bulk Consumers, and PCMs having different purchase and disposal mechanisms.

P1.1 Three sources of e-waste

Evidence from the field (NVivo node: *P1- Three sources (Retail, Bulk, Manufacturers)*)

Evidence from primary sources reveal that retail consumers, bulk consumers, and PCMs (Products & Components Manufacturers) are sources of e-waste. This is based on the responses by various stakeholders including PCMs, Formal Processors, Government Officials, and Bulk Consumers (#1, #2, #3, #4, #5, #6, #7, #8, #9, #10, #13, #14, #15, #16, #17). Retail Consumers include individual consumers of e-products and Bulk Consumers include large consumers of e-products like banks, hospitals, public and private companies, etc. Manufacturers of e-products also generate e-waste through defective products i.e. products not meeting quality standards. This set of manufacturers also include component manufacturers. For example, manufacturers of PCBs generate defective PCBs that gets into e-waste stream. Data from secondary sources also corroborates this evidence obtained from primary sources (#20 to #26).

P1.2 Other sources of e-waste: Imports

Evidence from the field (NVivo node: *Other Sources of e-waste*)

Interestingly, a fourth source of e-waste emerged from field evidence. The fourth source of e-waste is imports from foreign countries. This is evident based on the responses by various stakeholders including Government Officials, Formal Processors, and Manufacturers (#1, #2, #4, #5, #8, #9, #10, #11). E-waste is imported legally through ports. Legal import of e-waste implies importing through ports by complying with provisions in the export-import law and simultaneously gaming the system.

It is worthwhile to understand how e-waste imports occur by complying with the legal provisions. As per the legal provisions (like Basel Convention), importing second-hand goods are legal. Much of imported e-waste is actually not second-hand goods. Rather, the containers

are labelled (or disguised) as second-hand goods or electronic scrap (which cannot be reused) is mixed with genuine second-hand goods or the containers with electronic scrap are labelled as having mixed metal scrap. These imports eventually end up with the Informal Processors or Formal Processors through the e-waste RSC. Formal Processors also have provisions to import e-waste for processing. For example, MoEF with the permission from Directorate General of Foreign Trade had allowed Attero Recyclers (a Formal Processor) to import 8,000 tonnes of e-waste (Mudur, 2009). One of the policy makers who drafted EMHR had fought with the Government to allow import of e-waste in India (#8). An interesting observation is e-waste also enters the country as components of other products. For example, e-waste gets into the country through ships when the ship halts for repair or dismantling in ship breaking yards (#9, #11). This is mode of e-waste entry is outside the purview of e-waste legislations or any specific export-import laws.

Evidence from secondary sources (for example, #12 to #18; #21 to #23; etc.) corroborates the "legal import" of e-waste using provisions in the law. E-waste from Nepal is also being sold to processors in India through the supply chain of scrap traders (#46).

Evaluation: Evidence was found to support this proposition. But, apart from the sources listed in the proposition, one more source was found i.e. imports from other countries. A complete evaluation of this proposition is possible only after evaluating P2, P3, and P4. i.e. sources of e-waste having different purchase and disposal mechanisms can be understood only through evaluation of P2, P3, and P4. This proposition is revised as follows in Table 44.

Table 44: Evaluation of Proposition 1

Original proposition	*P1: Sources of e-waste are Retail Consumers, Bulk Consumers, and PCMs having different purchase and disposal mechanisms.*
Revised proposition	*P1: There are four sources of e-waste: Retail Consumers, Bulk Consumers, PCMs, and Imports.*

Proposition 2

P2: Retail Consumers purchase from retailer channels (online and offline) at maximum retail prices in small quantities.

Evidence from the field (NVivo node: *P2- How retail consumers purchase*)

Responses from various stakeholders revealed that individuals and households purchase e-products from retailers through online (i.e. e-commerce firms) and offline channels (i.e. brick-and-mortar stores) for their personal use in small quantities (#1 to #7). There was no corroboration of this evidence from secondary sources.

Evaluation: Support was found for this proposition, based on field evidence. This proposition is revised, to improve precision, as follows in Table 45.

Table 45: Evaluation of Proposition 2

Original proposition	*P2: Retail Consumers purchase from retailer channels (on-line and off-line) at maximum retail prices in small quantities.*
Revised proposition	*P2: Retail Consumers purchase from e-commerce stores (online) and brick-and-mortar stores (offline) at maximum retail prices in small quantities.*

Proposition 3

P3: Bulk Consumers purchase from dealers, authorised by manufacturers/importers, in large quantities through some contracts.

Evidence from the field (NVivo node: *P3- How bulk consumers purchase*)

P3.1 Bulk Consumers purchase in large and small quantities

Typically, Bulk Consumers purchase e-products in large quantities (#8, #9, #12, #15). However, field evidence also revealed that Bulk Consumers purchase in small quantities (one or two) by having tie-ups with retailers (#1, #4, #5). Manager of the Electrical section at MIB, illustrated their purchase process using the example of a hostel renovation that was currently going on:

"For hostel renovation, we float tenders and the selected contractor purchases all the items [fans, tube lights, etc.]. When these items get old or damaged, we replace them. For this, we purchase items and maintain some stock. The stores department has annual rate contracts with vendors. We purchase from these vendors at prices below the maximum retail price." – (#5).

The respondent also said that the stores department purchased the requested items (requests coming from other departments) from select vendors when needed (#4). The inference from #5 and #4 is that these quantities may not be high i.e. typically, the stores department will not be ordering for 100 fans in a single transaction. They would be ordering in small quantities (say 10 fans, 10 tube lights, etc.) whenever there is a request placed from other departments. Nevertheless, possibility of quantity discount contracts cannot be ruled out. The point to be noted is this: there are situations where Bulk Consumers purchase in small quantities.

P3.2 Bulk Consumers purchase from manufacturers and dealers

Bulk Consumers purchase from manufacturers and dealers through contracts. These contracts imply price agreements and the price paid is always less than the product's maximum retail price. This is evident from comments #1, #3, #4, #5, #6, #8 to #15. For example, the Bulk Consumer MIB purchases IT products from authorized dealers (i.e. dealers who are authorized

by the manufacturer). Many Bulk Consumers require enterprise-edition products which are not sold by retailers. Such products are only available directly from manufacturers or authorized dealers. For example, Sr. Manager (Sustainability) at OIP said:

"Big companies do not go to dealers...because their quantum is huge...quantum is in the range of some 1000s...so, you don't go to a dealer...you go to the manufacturer directly. For example, if I am procuring some 1000s of laptops every month, there is no point in going to dealers...so, we directly talk to the local contact point of the manufacturer." - (#9).

Interestingly, field evidence revealed a concept known as "bonding" i.e. Bulk Consumers (organizations) located in SEZs (Special Economic Zones) are entitled to import e-products without paying any import duty, but they cannot sell it in the market after using these products. This concept is called bonding (#6, #7, #8, #10). The e-products purchased using this route are bonded with the respective Bulk Consumer. Many Bulk Consumers import e-products to meet their needs for high-tech, high quality, high performance equipment to run their business efficiently. This is also corroborated by evidence from secondary sources.

Evaluation: Though overall support was found for this proposition, field evidence led to better understanding of certain nuances. It was found that Bulk Consumers purchase in large and small quantities (vide P3.1). It was also found that Bulk Consumers purchase directly from manufacturers or authorized dealers (vide P3.2). These purchases are based on contracts i.e. agreements negotiated based on price and quantity. The price paid by Bulk Consumers are less than maximum retail prices (vide P3.2). This proposition is revised as follows in Table 46.

Table 46: Evaluation of Proposition 3

Original proposition	*P3: Bulk Consumers purchase from dealers, authorised by manufacturers/importers, in large quantities through some contracts.*
Revised proposition	*P3 (a): Bulk Consumers purchase from manufacturers and authorized dealers in large quantities through contracts* *P3 (b): Bulk Consumers also purchase from authorized dealers in small quantities through contracts* *P3 (c): Bulk Consumers pay less than maximum retail prices* *P3 (d): Bulk Consumers located SEZs import e-products without paying import duty and these products remain bonded with them after use*

Proposition 4

P4: Manufacturers of electrical and electronic products produce defective products that enter e-waste stream.

Evidence from the field (NVivo node: *P4- How manufacturers generate*)

Manufacturers include end-product manufacturers (#6, #7); component manufacturers like PCB manufacturers, EMS (Electronic Manufacturing Services) firms, etc. (#2, #4, #7, #11, #13, #19); authorized refurbishers (#8). End-product manufacturers imply brands (ex: Apple, Microsoft, Samsung, etc.) where components are imported and assembled and "real" manufacturing does not take place (#3, #7, #10). In essence, all these manufacturers exist in the forward supply chain of e-products manufacturing i.e. from the embedded system or chip design firms to end-product manufacturers. E-waste generated by these manufacturers can be products like laptops, desktops, etc. (#10, #7, #19), components like microchips, PCBs, etc. (#1, #3, #4, #7, #10, #19), and waste by-products from manufacturing (#6, #7, #11, #15). The discarded products or components can be functional (#4, #9) or non-functional (#9, #12, #13, #14). Defective products, returned products, out-of-warranty products, products that could not be sold due to technological obsolescence or not meeting customer requirements are generated by manufacturers (#9). E-waste generated by manufacturers can also be worn-out machines and other equipment used for manufacturing, like panel boards of CNC machines, wires, monitors, batteries, computers, iron items, electrical items, etc. (#1). This is also corroborated by data from secondary sources. While developing this proposition, we had only hypothesized regarding product manufacturers (i.e. manufacturers of end-products like mobile phones, televisions, etc.). But, field evidence revealed the presence of component manufacturers (i.e. manufacturers of printed circuit boards, chips, etc.) in the RSC.

Evaluation: Though overall support was found based on field evidence, this proposition needs revision to capture more nuances. This proposition is revised as follows in Table 47.

Table 47: Evaluation of Proposition 4

Original proposition	*P4: Manufacturers of electrical and electronic products produce defective products that enter e-waste stream.*
Revised proposition	*P4 (a): Manufacturers that exist along the forward supply chain of e-products (i.e. PCMs) generate e-waste.* *P4 (b): This e-waste consists of products, components, and waste by-products during manufacturing.* *P4 (c): The disposed products and components can be functional or non-functional.*

Proposition 5

P5 (a): The economic value of products discarded by consumers (retail and bulk consumers) depends on its functionality, demand in second-hand market, design modularity.

P5 (b): Functional products have higher economic value than non-functional products.

P5 (c): Functional products with high demand in second-hand market have higher economic value than functional products with low demand in second-hand market.

P5 (d): Products with high design modularity have higher economic value than products with low design modularity.

Evidence from the field (NVivo nodes: *P5(a), P5(b), P5(c), P5(d), Others*. Unless specified, the references are from *Other factors influencing economic value*)

P5a.1 Economic value of discarded products depends on its functionality, demand in second-hand market

The dependence on functionality and demand in second-hand market is evident from #1[Appendix P5(a)], #1[Appendix P5(b)], #29, #31, #42, #58, #66. For example, Retailer decides the price of used phones returned by consumers based on the condition of phone, its age, if it is fully-functional or half-functional, and demand in the second-hand market (#1)[Appendix P5(a)]. Demand on second-hand market need not be for products alone, even parts/components inside the product would have demand in the second-hand market (#68). An interesting finding is regarding the demand of products in second-hand market. Functional products of foreign brands have higher demand in second-hand market (and consequently higher economic value) when compared to functional products of domestic brands. For example, Proprietor of COOL said regarding foreign and domestic brands:

"Look at this [showing a Sony laptop]...this finishing you will not get [in domestic brands]...branded ones will have smooth finishing, good thickness, the quality of plastic is good...in other brands [domestic brands], quality of plastic will be low, finishing will not be

proper...that is what I mean by quality...the steel will be more thick [in foreign brands]...in other brands, it will be thin [low thickness]", "these Samsung, LG, Sony...it is easy to make money from these branded ones...one can make good money. From other brands also, money can be made...but, not so much." – (#31).

P5a.2 Economic value of discarded products depends on the commodities inside products

This is based on evidence from various stakeholders including formal processors and informal processors (for example, comments #2, #5, #10, #11, etc.). A processor decides the value (i.e. how much money to be paid to the consumer) of a CRT monitor (cathode ray tube found in television and desktop computers) based on the quantity of glass, plastic casing, and copper (inside the yolk) inside that monitor and at what price the glass, plastic, and copper could be sold in the market. For example, if Rs. 200 can be expected to be made by selling glass, plastic, and copper from 1 CRT monitor, the processor adds transportation, labour, and other processing costs, and would be willing to pay Rs. 100 for that CRT monitor. Generally, consumers disposing CRT monitor would ask for an amount higher than Rs. 100 and the processor may oblige by paying slightly higher than Rs. 100 by taking into account his expected profit. This economic value of the product based on its commodities, is popularly known as "scrap value". This is irrespective of whether the product is functional or not. This pricing logic (i.e. logic of computing the scrap value or commodity value) is applicable when the processor is doing only disassembly and the products or its components are not sold in second-hand market (#64, #66). As such, this "scrap value" or commodity value depicts the pricing for worst-case scenario for the processor i.e. if the products/components (comprising e-waste) purchased by the processor cannot be sold in second-hand market, he can expect to earn a minimum amount by disassembling the products and selling the commodities. This logic of computing economic value based on commodities inside, is prevalent in transactions between stakeholders across the e-waste RSC. Apart from Bulk Consumers to Processors, this pricing logic also extends to the following: Processors to Scrap Metal Traders who will further sell to Foundries or Smelters (#3, #16, #27, #56, #77, #81), Processors to Precious Metal Refiners (#44, #51, #65, #98). Evidence from secondary sources corroborates this pricing logic based on commodities (#114, #115, #122).

P5a.3 Some products have positive salvage value, while some products have negative salvage value

Salvage value of a product = (economic value obtained after processing) – (processing costs). For products with positive salvage value (ex: laptops, computers, etc.), the costs of processing is less than the economic value obtained after recovery. Products with negative salvage value (ex: tube lights, bulbs, etc.) have higher processing costs than the economic value obtained after recovery. E-waste sources (Bulk Consumers, Retail Consumers, and Manufacturers) have to pay e-waste collectors/processors for disposing products with negative salvage value. Generally, collectors/processors nets it off with the positive salvage value items. For example, if a Formal Processor purchases e-waste from a Bulk Consumer, the cost of negative salvage value products are subtracted from the price offered for positive salvage value products. These are evident from comments #1, #17, #19, #35, #38, #49, #52, #58, #69, #70, #74, #88, #101. Data from secondary sources corroborates this (#120, #122).

P5a.4 Incomplete information

Stakeholders across the e-waste RSC constitutes *sellers* and *buyers* (the terms 'sellers' and 'buyers' are abstractions). The sellers and buyers do not have complete information regarding the potential yield that can be made from e-waste after processing. Sometimes, the stakeholders also lack understanding of what commodities inside e-waste products can be sold in the market. The seller-buyer pairs include Formal Processor and Precious Metal Refiner, Bulk Consumer and Processor (Informal or Formal). For example, Co-founders of AMY (a Formal Processor) said regarding his transaction with a Bulk Consumer:

"There have been cases where our valuation had gone wrong…we would have anticipated so much amount of metal in a material and would have quoted higher….after dismantling we find that the quantity of metal is lower than we anticipated….and we make losses…there is lot of uncertainty involved in this business." – (#47).

These are evident from comments #5, #26, #30, #42, #44, #47, #50, #51, #66. Doing a chemical analysis of sample before purchasing the entire lot, reduces this informal asymmetry for the processors (#26, #50, #56). Data from secondary sources corroborate this idea of information

asymmetry and need for chemical analysis to accurately understand the composition of commodities (#113).

P5a.5 Formal processors pay less when compared to informal processors

Formal Processors pay less when compared to Informal Processors for the same e-waste. This is because operational costs are very low for Informal Processors. This is evident from #12, #15, #32, #45, #57, #58, #73, #84, #86, #89, #93. For example, if an Informal Processor can purchase one product by quoting Rs. 700, a Formal Processor can only pay Rs. 350 for that product (#12). This is due to high operational costs (ex: investment in facility, costs of running facility, taxes on purchase and sale, etc.) incurred by the Formal Processor (#12). Evidence from secondary sources corroborates this (#116).

P5b Functional products have higher economic value than non-functional products

This is evident from #2 [Appendix P5(b)], #33, #95, #96. For example, Officer in the IT section at MSB said that totally damaged (i.e. not functional) LCDs, keyboards, batteries, adapters, etc. cannot be used again and Processors do not pay anything for such products. Evidence from secondary sources corroborates this finding (#3 & #4 from Appendix P5(b)). Thus, field evidence supports P5(b).

P5c Functional products with high demand in second-hand market have higher economic value than functional products with low demand in second-hand market

This is evident from #1[Appendix P5(c)], #2 [Appendix P5(c)], #29, #33. For example, a functional Blackberry phone (which uses CDMA technology) does not have demand in second-hand market and can only be sold to a Scrap Trader for Rs. 500. This is because the technology has become obsolete and CDMA is not popular. In another example, there is high demand in the second-hand market for computers running on Core i3, i5, i7 processors. Products running on Core 2 duo, Pentium IV, and Pentium III processors have low demand in second-hand market when compared to Core i3, i5, i7 processors. Consequently, the economic value of products running on Core i3, i5, i7 processors are higher when compared to other old-generation processors. Evidence from secondary sources corroborates this (#3[Appendix P5(c)], #105, #106, #111, #112). Thus, support for P5(c) was found from field evidence.

P5d Products with high design modularity have higher economic value than products with low design modularity

Generally, there is no demand for Sun Microsystems's products, Apple's products in the second-hand market (#14). This is because their operating systems (Solaris, Mac) are not widely used like the Windows (#14). However, if there are specific buyers who are keen to buy such products, it will be sold in the second-hand market (#14). Products with modular designs (HP, IBM, Dell, etc.) have higher demand in second-hand market when compared to Apple's and Sun's products (#14). Interestingly, the scrap value of products with modular designs (ex: printers of HP, Samsung, etc.) are low due to lower quality and quantity of commodities used inside their products (#14). But, scrap value of products with integral designs (ex: printers of Sun Microsystems) are high due to higher quality of commodities. Thus, a more nuanced evidence was found to support P5(d) and revise it.

Evaluation: At each sub-section, evaluation has been done. These propositions are revised as follows in Table 48.

Table 48: Evaluation of Proposition 5

Original proposition	*P5 (a): The economic value of products discarded by consumers (retail and bulk consumers) depends on its functionality, demand in second-hand market, design modularity.* *P5 (b): Functional products have higher economic value than non-functional products.* *P5 (c): Functional products with high demand in second-hand market have higher economic value than functional products with low demand in second-hand market.* *P5 (d): Products with high design modularity have higher economic value than products with low design modularity.*
Revised proposition	*P5 (a): Economic value of discarded products depends on its functionality, demand in second-hand market, brand origin, commodities inside, and salvage value.* *P5 (b): Functional products have higher economic value than non-functional products.* *P5 (c): Functional products with high demand in second-hand market have higher economic value than functional products with low demand in second-hand market.* *P5 (d1): Functional products with high design modularity have higher economic value than functional products with low design modularity.* *P5 (d2): Products with high design modularity have lower commodity value than products with low design modularity.*

	P5 (e): Functional products of foreign brands have higher demand in second-hand market when compared to functional products of domestic brands. *P5 (f): Some products have positive salvage value, while some products have negative salvage value.* *P5 (g): Processors have incomplete information regarding yield of commodities from e-waste and market knowledge of commodities inside e-waste*

Proposition 6 (a)

P6 (a): Retail consumers have six options to dispose e-waste: stock-up at home, sell to door-to-door collectors, sell to retailers, give to formal processors, return to manufacturers, or combine with municipal solid waste.

Evidence from the field (NVivo node: *P6(a)*)

Evidence from stakeholders revealed the six options of e-waste disposal, as hypothesized in this proposition. Each disposal option is elaborated below:

- Stock-up at home: This means that some e-waste remains idle at home irrespective of whether it is functional or non-functional. Retail Consumers hoard or stock-up this e-waste. This is evident from comments #9, #15, #20, #26, #31.

- Sell to Door-to-Door Collectors: Some e-waste is sold to Door-to-Door Collectors who exist in every neighbourhood in the country. They are popularly called as "kabaadiwalla" or the small scrap traders who collect e-waste and other items like metals, plastics, glass, paper, etc. This is evident from comments #16, #27, #30, #31, #32, #36. For example, during BB's collection drive at an IT MNC, a retail customer said that, he had disposed broken television to a scrap trader in his neighbourhood (#32).

- Sell to Retailers: E-waste is also sold to retailers in exchange for new products (i.e. getting price discounts on the new products) or without any exchange offers. This is evident in comments #3, #8, #12, #14, #15, #16, #18, #29, #31.

- Give to Formal Processors: E-waste can be disposed to Formal Processors in three ways. Disposing in collection centers or bins set-up by NGOs, Governmental organisations (#6, #16, #31, #35, #38); disposing in collection centers or bins run by for-profit e-waste collection firms (#9, #21, #23, #24, #30, #31, #32, #33, #34, #36); disposing in collection centers or bins run by Formal Processors (#11, #37). Generally, the collection centers (whether run by NGO, Government, or for-profit collection firm) claim to send the collected e-waste to Formal Processors. For example, Retail Consumers had disposed e-waste in bins, during BB's collection drive at an IT MNC (#34). BB had a tie-up with a Formal Processor to sell the collected e-waste (#30).

- Return to manufacturers: This is done by disposing in manufacturer-operated collection centers (#13, #17, #25). For example, LED (a large IT hardware manufacturer) has 20 service centers that accept end-of-life IT products. Retail Consumers can bring their non-functional IT products of any brand and drop in bins located inside the 20 service centers.

- Combine with municipal solid waste: Some e-waste is dumped along with municipal waste. These are disposed in municipal waste bins or given to municipal waste collectors. This is evident from comments #15, #31.

Others disposal options that were revealed are Gift to friends, relatives (#1, #4, #15); Sell to other Retail Consumers (#20); Donate to NGOs, schools, etc. (#15). Evidence from secondary sources corroborated the evidence obtained from primary sources for each disposal option: Stock-up at home (#46, #48, #49, #50, #53, #55, #59, #64); sell to door-to-door collectors (#41, #42, #43, #44, #45, #48, #50, #54, #60, #61); sell to retailers (#39, #45, #47, #49, #50, #63); give to formal processors by disposing in collection centres (#52, #59, #62, #65); return to manufacturers (#66); combine with municipal solid waste (#39, #41, #42, #43, #44, #48, #49, #50, #55); gift to friends, relatives (#39, #40, #47, #48, #49); sell to other retail consumers (#40, #45, #48, #50); donate (#39, #40, #51).

Evaluation: Support was found for this proposition from field evidence. However, more nuances were obtained from the field that led to understanding of more disposal options: Gift to other Retail Consumers; Sell to other Retail Consumers; Donate to Bulk Consumers. Gifting and selling to other Retail Consumers or Bulk Consumers mean that the stage of RSC has not changed i.e. e-waste would continue to exist in Sources stage. This proposition is revised as follows in Table 49.

Table 49: Evaluation of Proposition 6 (a)

Original proposition	*P6 (a): Retail consumers have six options to dispose e-waste: stock-up at home, sell to door-to-door collectors, sell to retailers, give to formal processors, return to manufacturers, or combine with municipal solid waste.*
Revised proposition	*P6 (a): Retail consumers have nine options to dispose e-waste: stock-up at home, sell to Door-to-Door Collectors, sell to Retailers, give to Formal Processors, return to Manufacturers, combine with municipal solid waste, gift to other Retail Consumers, sell to other Retail Consumers, donate to Bulk Consumers.*

Proposition 6 (b)

P6 (b): Low volume products with low economic value are stocked-up at home or disposed along with municipal solid waste.

Evidence from the field (NVivo node: *P6(b)*)

P6b.1 Products disposed along with municipal solid waste

Low volume products like tube lights, bulbs, CFLs, small batteries, after its use have low economic value (i.e. they cannot be monetized by the consumer). They are usually disposed along with municipal solid waste. This evident from comments #1, #2, #3, #4, #5, #7, #8, #9, #10. Though it was hypothesized that these low volume products have negligible economic value, field evidence have proved otherwise i.e. these products do have some economic value (commodity value or scrap value). Though these products are disposed along with municipal solid waste, it is collected by Waste Pickers and sold to Scrap Traders. This is discussed in detail in the section Path Dependence (Theme 7 in Chapter 5). Products with high economic value (i.e. they can be monetized by the consumer) are not disposed along with municipal solid waste. This is evident from comments #2, #3. For example, PCB boards, copper wires, aluminium wires, products with metal casing, etc. are sold to Door-to-Door Collectors and not disposed along with municipal solid waste (#3).

Evidence from secondary sources corroborates low volume, low economic value products like CFLs, tube lights, pencil batteries, etc. being disposed along with municipal solid waste (#11, #12, #13, #14, #16, #17) and high economic value products not being disposed along with municipal solid waste (#15).

P6b.2 Products that are stocked-up at home

Low volume products that are functional and not currently used, tends to get stocked-up (#6). For example, Retail Consumer 2 decided to dispose his non-functional laptop in the e-waste collection centre. But, he did not dispose his wireless router, digital camera that are functional and not currently used (#6). Low volume products that are non-functional also gets stocked-up. For example, broken toys that are battery operated, damaged video game consoles, etc.

(#6). Such products were stocked-up because their volumes are low and do not occupy much space (#6). Another aspect of product that are stocked-up is the perceived economic value attached to it by consumers. For example, Retail Consumer 2 said regarding stocking-up of an expensive bulb:

"A bulb fuses...you take it and put it in the trash can...it's easy to throw it...100 bucks bulb, ok you actually throw it...2000 bucks, not working, you don't throw...and you tend to keep it." – (#6).

Evaluation: Partial support was found for this proposition. For example, support was found for low volume products with low economic value being disposed along with municipal solid waste (vide P6b.1). In addition to this, field evidence revealed the existence of high perceived economic value for stocking-up (vide P6b.2). Hence, this proposition is revised as follows in Table 50.

Table 50: Evaluation of Proposition 6 (b)

Original proposition	*P6 (b): Low volume products with low economic value are stocked-up at home or disposed along with municipal solid waste.*
Revised proposition	*P6 (b1): Low volume products with low economic value are disposed along with municipal solid waste.* *P6 (b2): Low volume products with high perceived economic value are stocked-up at home.*

Proposition 6 (c)

P6 (c): Low volume products with high economic value are stocked at home or sold to retailers.

Evidence from the field (NVivo node: *P6(c)*)

Low volume products with high economic value (ex: end-of-use mobile phones) are sold to (i.e. exchanged or monetized) retailers. This evident from comments #1, #2, #3, #4, #5, #6, #16. Apart from such products, high volume products with high economic value are also sold to retailers. This is evident from comments #3, #5, #6. For example, Retail Consumer 1 had exchanged an old refrigerator for a new one, eight years ago (#3).

Low volume products with high economic value are also stocked-up. This is evident from comments #5, #10, #13, #14. Low volume, end-of-use functional products tends to get stocked-up at home (#9). For example, Retail Consumer 2 spoke about his functional wireless router and digital camera that are stocked-up at home even though he does not use them (#9). This is because volume of such products are low and can be easily stocked-up (#9).

Interestingly, as found in the previous proposition, certain low volume products irrespective of their economic value tends to get stocked-up due to the perceived economic value (ex: sentimental value) attached to them by consumers (#9, #11, #12).

Evaluation: Though support was found for this proposition, evidence from the field revealed more nuances. For example, perceived economic value was again found to be an important concept. This proposition is revised as follows in Table 51.

Table 51: Evaluation of Proposition 6 (c)

Original proposition	*P6 (c): Low volume products with high economic value are stocked at home or sold to retailers.*
Revised proposition	*P6 (c1): Low volume products with high economic value are stocked-up at home or sold to retailers.* *P6 (c2): High volume products with high economic value are exchanged with retailers* *P6 (c3): Low volume products with high perceived economic value are stocked-up at home.*

Proposition 6 (d)

P6 (d): High volume products with high economic value are sold to door-to-door collectors or retailers.

Evidence from the field (NVivo node: *P6(d)*)

High volume products with high economic value (e.g., refrigerators, washing machines, freezers, televisions) are sold to (exchanged or monetized) Retailers or Door-to-Door Collectors. This is evident from comments #3, #4, #7, #10, #12. High volume products with high economic value (ex: monitors, geysers, washing machine, dot-matrix printer) are also stocked-up waiting for a Door-to-Door Collector. This is evident from comments #4, #17, #18. For example, Retail Consumer 1 was waiting for a collector to pick-up the monitors he has been stocking-up at home. These monitors were stocked-up due to space availability. High volume products with high economic value (ex: computers, laptops) are also donated (#7). These were corroborated by evidence from secondary sources (#23).

Evaluation: Support was found for this proposition based on field evidence. However, more nuances (e.g., stocked-up and waiting for collectors) were found that enriched our understanding. This proposition is revised as follows in Table 52.

Table 52: Evaluation of Proposition 6 (d)

Original proposition	*P6 (d): High volume products with high economic value are sold to door-to-door collectors or retailers.*
Revised proposition	*P6 (d1): High volume products with high economic value are sold to door-to-door collectors or sold to retailers or donated.* *P6 (d2): High volume products with high economic value are also stocked-up, waiting for Door-to-Door Collectors.*

Proposition 7(a)

P7 (a): Bulk consumers have six options to dispose e-waste: stock-up at warehouse, conduct auctions, contract with scrap dealers, contract with formal processors, return to dealers, or combine with municipal solid waste.

Evidence from the field (NVivo node: *P7(a)*)

P7a.1 Bulk Consumers stock-up e-waste at closed rooms and open yards

Evidence from primary sources reveal that Bulk Consumers stock-up e-waste at closed rooms (this means 'store rooms') and open yards. These are within the premises of Bulk Consumers. This is evident from comments #37, #46, #47, #52, #111. For example, at MIB the IT hardware (ex: computers, laptops, printers, servers, etc.) are dumped in a closed room while other products (ex: ceiling fan, exhaust fan, refrigerators, chairs, tables, etc.) are dumped in an open yard. Evidence from secondary sources corroborates this (#70, #74, #76, #82, #104, #106, #108).

Therefore, there is evidence that Bulk Consumers stock-up e-waste at closed rooms and open yards.

P7a.2 Bulk Consumers conduct auctions to dispose e-waste

Evidence from primary sources reveal that Bulk Consumers conduct auctions. Bulk Consumers conduct auctions by themselves or outsource it to a third-party like MSTC, MatexNet, etc. The Processor who quotes the highest amount will be able to purchase the e-waste. Auctions are done generally done in two ways: open auction and inviting sealed tenders. These are evident from comments #19, #23, #24, #33, #42, #43, #49, #50, #56. This auctioning of e-waste where Processors pay to the Bulk Consumers is unique to countries like India (#19). Bulk Consumers in European Countries need to pay Processors to dispose their e-waste (#19). An interesting observation here is the case of TAT, a large-size Telecom MNC. The Associate with TAT said that their US Head Quarters had decided on a single Formal Processor to whom all their offices across the world would give e-waste (#47). In this transaction, TAT pays money to the Formal Processor for taking their e-waste (#47). Though the Bangalore office of TAT would like to

"sell" this e-waste to a Formal Processor who pays the highest amount, they do not have the authority to override the decision taken at US Head Quarters.

Some Bulk Consumers (ex: MNC Bulk Consumers) decides which Formal Processors can participate in auctions. For making this decision, non-monetary issues are evaluated. For example, certification by external agencies (ISO, R2, etc.), auditing their processing facility to ensure e-waste is processed scientifically, etc. These are evident from comments #26, #29, #31, #52. Evidence from secondary sources corroborates this (#63, #64, #74, #84, #85, #86, #94, #108).

Therefore, there is evidence that Bulk Consumers conduct auctions to dispose e-waste.

P7a.3 Bulk consumers contract with scrap traders to dispose e-waste

We did not find any evidence of Bulk Consumers establishing long-term contracts with scrap traders[35]. But, sometimes scrap traders directly approach Bulk Consumers and pick e-waste. Mostly, these scrap traders are Door-to-Door Collectors who collect from households and small offices. This is evident from #3, #45, #51. Sometimes, these scrap traders can themselves be Informal Processors. They approach Bulk Consumers directly and purchase e-waste through auctions or without auctions (depending on what Bulk Consumers decide). This is evident from comments #23, #34, #37, #43. For example, some products like CFLs, fans, etc. are not listed as e-waste in EMHR. So, MIB disposes products like fans, motors, etc. (not listed as e-waste in EMHR) to scrap traders (#43).

Evidence from secondary sources corroborates this (#57, #61, #72, #74, #79, #83, #94, #102, #106). Therefore, there is evidence that Bulk Consumers sell e-waste to scrap traders as single-shot transactions or by conducting auctions.

P7a.4 Bulk Consumers contract with formal processors to dispose e-waste

[35] The original proposition had the term 'scrap dealers'. However, field evidence led us to modify this to 'scrap traders'. Also, Dealers are considered as a separate stakeholder in the RSC.

Evidence from primary sources reveal that Bulk Consumers establish long-term contracts with formal processors i.e. contracts are signed for a period of 1-3 years in which a specific price is decided for each type of e-waste. This is evident from comments #30, #33, #47. Apart from this, there is also evidence that Bulk Consumers sell their e-waste to formal processors without any long-term contracts i.e. single-shot transactions. This is evident from comments #1, #3, #4, #26, #27, #28, #35, #36, #38, #55.

Evidence from secondary sources corroborates this (#57, #72, #74, #79, #86, #102, #105, #107). Therefore, there is evidence that Bulk Consumers sell e-waste to Formal Processors with or without long-term contracts.

P7a.5 Bulk Consumers return e-waste to dealers or manufacturers

Evidence from primary sources reveal that some Bulk Consumers return e-waste to dealers (from whom Bulk Consumers have purchased) or manufacturers. Sometimes, Bulk Consumers have annual maintenance contracts (to replace or repair e-products) with their respective dealers. This is evident from comments #3, #37, #42, #49. For example, Product Take-back Manager of LED said:

"We also have Asset Resale and Recycling service for bulk consumers...the bulk consumer can call us, we will destroy their data…if the products have value, we will give money to bulk consumer, else it is recycled." – (#49).

Secondary sources corroborates this (#73, #83, #97). For example, Subramanian (2014) cited the Proprietor of an IT firm regarding exchanging e-waste with dealers:

"We replace it with new equipment and the seller takes it back. It is not like a buyback agreement, we buy new equipment and ask them to take the old ones for which they give some cost" – (#83).

Therefore, there is evidence that bulk consumers return e-waste to manufacturers or exchange with dealers.

P7a.6 Bulk Consumers dispose e-waste along with municipal solid waste

Evidence from secondary sources reveal that Bulk Consumers dispose e-waste along with municipal solid waste (#58, #59, #60, #103). For example, a news article reported about a bulk consumer (a Government organization) disposing e-waste (high value and low value products) in a nearby garbage depot (Daily News & Analysis, 2013). The e-waste included: *"computer parts, pencil cells, CFL batteries, spare parts of mobile phones, laptops, radio, television, refrigerators, used bulbs, capacitors and other domestic and industrial electronic waste."* This evidence does not mean that these products end up in open landfills. These would be collected by Waste Pickers and sold to Scrap Traders (this is explained in Theme 4 in Chapter 5).

Therefore, there is evidence to say that bulk consumers dispose e-waste along with municipal solid waste.

P7a.7 Other disposal options

<u>Donation to other bulk consumers:</u> Products that are functional and can be re-used (like laptops, desktops, etc.) are donated to educational institutions, schools, etc. as charity. This donation is done through an intermediary like NGO or Industry Associations i.e. Bulk Consumers give to this intermediary organization who would channelize it to appropriate organizations. This is also considered as part of CSR (Corporate Social Responsibility). An interesting observation made by Deputy Director of Manufacturers' Association was Bulk consumers who do not have purchase records of certain products, dispose those products in collection drives conducted by Formal Processors, NGOs, or e-waste collection firms (#9). Also, the intermediary organizations which collects e-waste from Bulk Consumers (charity purpose), do not always channelize it to appropriate needy organizations like schools. These are evident from #7, #9, #22, #29, #34. Evidence from secondary sources corroborates this (#57, #61, #72, #73, #75, #76, #78, #83, #96, #98).

<u>Sell to employees:</u> Products that are functional and can be re-used (like laptops, desktops, etc.) are sold to their own employees. This is evident from #8, #37. For example, Co-founder of RWM noted:

"Whatever is technologically obsolete, can be resold. Typically, they resell to their own employees...that's the first choice. If the employee don't pick up, then they give to someone else." – (#37).

Evidence from secondary sources corroborates this (#57, #61).

Therefore, there is evidence to say that bulk consumers also donate to other bulk consumers or sell to their employees (i.e. Retail Consumers).

P7a.8 Some characteristics of Bulk Consumers' e-waste disposal

Two departments: Bulk Consumers have two departments: IT and Administration (popularly referred to as "Admin" by the Processors) departments. They dispose e-waste separately. IT manages IT hardware (ex: computers, laptops, servers, UPS, etc.) and Admin manages other electrical and electronic products that includes utilities (ex: ceiling fans, tube lights, refrigerators, air conditioners, electricity wiring, etc.). These departments do not communicate with each other and dispose their e-waste separately. Informal or Formal Processors have to approach these departments separately to purchase e-waste. The reason for the separation of these two departments is because IT hardware is considered as asset items in the balance sheet, while utilities do not appear in the asset items of the balance sheet. This separation of departments also has implications for e-waste disposal. For example, MIB has two departments IT and Admin. IT Department has to comply with EMHR and dispose only to Formal Processors. But, Admin Department does not have to comply with EMHR (many products within this department do not fall under the EMHR) and disposes e-waste to Informal Processors or Scrap Traders. These are evident from #14, #26, #53, #54, #112, #113.

Hence, there is evidence that Bulk Consumers dispose e-waste through IT and Admin Departments separately.

Technological change influences e-waste disposal: This phenomenon (explained below) is popularly known as "technology refresh" in the industry. Many Bulk Consumers like IT firms, banks, etc. need to replace their old technology with recent one (ex: migrating to a new operating system platform, replacing computers having Pentium processors with computers

having latest Core i processors, etc.). For example, Sr. Manager (Sustainability) at OIP said about disposing office laptops used by the employees:

"Mostly after 4-5 years, we need to replace it...because, the technology will [become] obsolete and the performance [of existing laptop] will reduce drastically...and the computing power requirements will be more." – (#32).

These are evident from comments #17, #32, #36, #37. Data from secondary sources corroborates this (#57, #68, #69, #72, #75, #84). Hence, higher rate of technological change would lead to higher frequency of e-waste disposal.

<u>Purchase mechanism influences the disposal mechanism</u>: This the case of "bonded" e-waste. E-products that are purchased on import duty waiver cannot be sold to Processors easily. The Bulk Consumer has to pay the duty (or tax) for these products (this is directly proportional to the market value of the products) if he wishes to sell to Processors. This amount is higher when compared to the market value of the product and hence this option is seldom chosen by Bulk Consumers. Some Bulk Consumers store these products in the warehouse for a long time period so that the market value of these products reduce and can be sold to Processors after paying duty (or tax) to the Government. Otherwise, the only option left is to donate or destroy the products and sell as scrap. This is evident from comments #21, #26, #37. For example, Consultant X said:

"You can't sell it because the government has already given you lot of rebate on this. So, then what you need to do is you have to call the STPI [Software Technology Parks of India]…they have to come and how like you have this excise officers…they come, sit there, and in front of them you need to destroy this computer which is very good. Only then it can be sent out as scrap.", "they have to take hammer, hit it, and break it." – (#21).

Secondary sources corroborates this (#69, #70, #73, #74, #93, #100, #102, #106).

<u>Finance Department plays an important role in e-waste disposal</u>: Finance Department should agree to dispose the asset items (like computers, laptops, servers, etc.). For doing this, valuation of the asset should be equal to zero (through depreciation over a period of time). Only then, the assets are written-off from the accounts. Subsequently, the appropriate Department (IT or

Admin) starts their process of e-waste disposal. For example, in IT firms, computers are asset items. In 3 years their value becomes zero by depreciation i.e. the asset value becomes zero. Only then, they are given permission to be disposed. These are evident from comments #26, #47, #53. For example, Officer of IT section at MSB, who is responsible for disposing IT hardware said:

"[Suppose] I purchased a laptop of some $1,000...now, after 4 years if I'm saying that I need to scrap it, Finance needs to have a justification why I need to scrap it...once the justification is given to them, they will have to process it in their way...because, it is there in their books as an asset...so, you just cannot remove any asset from the company book...you need to have a process by the Finance, which will take care of the valuation of the current state of the asset with their depreciation value and stuffs like that, which Finance takes care...and then, they will let me know" – (#26).

Evidence from secondary sources corroborates this (#70, #77). For example, Subramanian (2014) cited Assistant Vice President (Admin Department) of a large IT firm speaking about disposing e-waste to manufacturer or processor (i.e. recycler):

"I think the manufacturer will be handling the waste better than the recycler. However, technically the auditor [Finance] will raise a question as why I am giving my end-of-life products for free when I can get some money from recycler" – (#77).

Evaluation: Though overall support was found for this proposition (vide P7a.1 to P7a.6), field evidence revealed more nuances regarding Bulk Consumers' e-waste disposal (vide P7a.7 and P7a.8). Hence, this proposition is revised as follows in Table 53.

Table 53: Evaluation of Proposition 7(a)

Original proposition	*P7 (a): Bulk consumers have six options to dispose e-waste: stock-up at warehouse, conduct auctions, contract with scrap traders, contract with formal processors, return to dealers, or combine with municipal solid waste.*
Revised proposition	*P7 (a1): Bulk Consumers have eight options to dispose e-waste: stock-up at open yards and closed rooms; conduct auctions; sell to scrap traders; sell to Formal Processors with or without long-term contracts; return to manufacturers or exchange with dealers; dispose along with municipal solid waste; donate to organizations; sell to employees.* *P7 (a2): Bulk Consumers dispose e-waste through IT and Admin Departments separately*

	P7 (a3): Technological change influences Bulk Consumers' e-waste disposal. Higher rate of technological change would lead to higher frequency of e-waste disposal. *P7 (a4): Bulk Consumers' purchase mechanism influence their disposal mechanism* *P7 (a5): Finance Department plays an important role in e-waste disposal*

Proposition 7(b)

> *P7 (b): Products with low economic value are stocked at warehouses or disposed along with municipal solid waste; products with high economic value are auctioned openly or contracted with scrap traders.*

Evidence from the field (NVivo node: *P7(b)*)

Products with high economic value are disposed to Processors (Informal or Formal) by conducting auctions (#1). Generally, Processors do not prefer to buy low value products like CFLs, tube lights, electronic choke, etc. that has low metal content (#1). This is due to the negative salvage value of those products i.e. processing costs are higher than the value that can be recovered. Sometimes, Bulk Consumers while disposing high value products, requests the Processors to also take their low value products. Some low value products like switches, fixtures, etc. can be sold to processors, because these are purchased as plastic scrap (#10). Sometimes, Bulk Consumer pays the Formal Processor for taking low value products (#39 [Node 7(a)]). Some Bulk Consumers mix high value and low value products and sell them to Processors. In this case, the Processor would pay a consolidated price to the Bulk Consumer (#39 [Node 7(a)]).

Evidence from secondary sources reveal contradictory evidence to what was hypothesized in the proposition. For example, some Bulk Consumers sell low value items like CFLs to scrap traders/informal processors (#58, #59, & #60 from [Node P7(a)]). A news article reported about a Bulk Consumer (a government organization) disposing e-waste (high value and low value items) in a nearby garbage depot (Daily News & Analysis, 2013). These included the following products: *"computer parts, pencil cells, CFL batteries, spare parts of mobile phones, laptops, radio, television, refrigerators, used bulbs, capacitors and other domestic and industrial electronic waste."* This evidence is contrary to conventional wisdom. This could be due to the influence of other moderating factors like space constraints to store e-waste, need for quickly liquidating unaccounted products due to an impending audit from external agency, etc. These conjectures are based on interviews with many stakeholders in this industry. Under normal circumstances, Bulk Consumers do not dispose high value products along with municipal solid waste.

Evaluation: Partial support was found for this proposition, based on the field evidence. This proposition is revised as follows in Table 54.

Table 54: Evaluation of Proposition 7(b)

Original proposition	*P7 (b): Products with low economic value are stocked at warehouses or disposed along with municipal solid waste; products with high economic value are auctioned openly or contracted with scrap traders.*
Revised proposition	*P7 (b1): Products with high economic value are sold to Processors by conducting auctions or otherwise* *P7 (b2): Products with low economic value are stocked-up or sold to Processors or disposed along with municipal solid waste*

Proposition 8

P8: Manufacturers destroy their defective products to prevent it from entering the market and then sell to scrap traders.

Evidence from the field (NVivo node: *P8*)

Manufacturers mean PCMs (Product and Component Manufacturers). PCMs dispose defective products and equipment used to manufacture those products. PCMs dispose their metal scrap and e-waste (i.e. electrical, electronic scrap) to Informal Processors (#1, #5, #7, #8). For example, PCMs dispose iron items like rods, electrical items like switches, computers, batteries, CNC machines, wires, etc. Sometimes, the products disposed by PCMs can be functional. For example, PCB manufacturers dispose functional PCBs, that no longer meet the customer requirement, to scrap traders (#5, #14, #15). In some PCMs, "real" manufacturing does not happen and only assembly is done. In such cases, the defective components would be returned to the respective suppliers (#4).

PCMs also dispose their e-waste to Formal Processors (#3, #6, #11). For example, Founder of RTH said that he buys defective products from foundries and also buys maintenance waste like cables, motors, meters, electronic chalks, etc. from manufacturing firms (#11). Founder of RTH also narrated his experience of destroying defective products from a PCM:

"Take the case of XYZ [a multinational high-tech manufacturer]...XYZ is a manufacturing company...they have household, electrical, electronics...all this is being manufactured in XYZ...sometimes, when the products are defective, they give to us...we destroy that material on-site...after coming to us, it should not be misused...if it goes outside and somebody else understands the formula, it harms them...we are doing proper recycling." – (#11).

Such experience of destroying defective products, was also narrated by the Proprietor of Alpha, while he worked in the informal economy. Evidence from secondary sources corroborated that PCMs sell e-waste or sometimes gives for free to Formal Processors (#17, #18).

Evaluation: Support was found for this proposition that PCMs destroy their defective products. However, field evidence led to a more nuanced understanding of PCMs disposing e-waste. This proposition is revised as follows in

Table 55: Evaluation of Proposition 8

Original proposition	*P8: Manufacturers destroy their defective products to prevent it from entering the market and then sell to scrap traders.*
Revised proposition	*P8 (a): PCMs dispose e-waste to Informal and Formal Processors* *P8 (b): Some PCMs mandates Processors to physically destroy their defective products on-site to protect their intellectual property*

Proposition 9

P9: Retailers collect functional and non-functional products only from retail consumers through buy-back and exchange schemes.

Evidence from the field (NVivo node: *P9*)

Retailers collect e-products from retail consumers and gives a discount when they purchase a new product or gives them a voucher which they can use to purchase new products from their store (this is called trade-in program). This is evident from comments #2, #3, #4, #8, #10, #11, #13. These include brick-and-mortar retailers like Girias, E-Zone, Croma, etc. and e-tailers like Flipkart, Amazon, etc. (#12). Some retailers prefer to give cash to retail consumers instead of exchange offers (#7). Sometimes, manufacturers mandate the retailers to keep bins where retail consumers can drop-in their products (comments #5, #6, #9). In such cases, Retail Consumers do not get discounts or vouchers for buying for new products. Retail Consumers can dispose functional and non-functional products in such bins. For example, Sustainability Head of AIK said regarding AIK's partnership with retailers to collect e-waste:

"We accept mobile phones and accessories of any brand…we bought this concept of collecting any brands for the first time. About 90% of what we collect are Chinese brands. We collect used phones and accessories through ABC Priority Dealer stores and ABC Care Centres. Bins are installed in these stores, for consumers to drop in products.", "We also have partnerships with small retail shops (not ABC)…we have partnerships with about 7000 such retailers across 16 cities." – (#9).

Evidence from secondary sources also reveal that retailers collect used products from retail consumers as exchange offers. This is evident from #14, #15.

Evaluation: Support was found for this proposition based on field evidence. However, there was no evidence obtained to evaluate if Retailers collect e-waste "only" from Retail Consumers. We also obtained evidence regarding the nature of transaction between Retailers and Retail Consumers. In light of these evidence, this proposition is revised as follows in Table 56.

Table 56: Evaluation of Proposition 9

Original proposition	*P9: Retailers collect functional and non-functional products only from retail consumers through buy-back and exchange schemes.*
Revised proposition	*P9 (a): Retailers collect functional and non-functional products from retail consumers* *P9 (b): Some Retailers give cash, some have exchange offers or trade-in programs.*

Proposition 10

P10: Retailers and dealers sell e-waste only to scrap traders because they receive higher payment.

Evidence from the field (NVivo node: *P10*)

P10.1 Scrap Traders purchase e-waste from Retailers, Dealers and from other stakeholders

PCMs sell customer rejected products, defective products, and other e-waste to scrap traders (comments #2, #14). Retailers sell the products returned by retail consumers to scrap traders. This is evident from comments #6, #7, #9, #11, #12, #17, #22, #24, #26. For example, Consultant X narrated the operations of a big-box retailer in Bangalore:

"they were collecting all kinds of waste…they were just giving it like scrap to anybody…whoever comes…whoever gives more money they used to give it and they made money out of it." – (#6).

AMO, an Electronics Retail Chain that operates at a national level, and other retailer chains (including e-commerce retailers) sell the customer returned products to a scrap trader COOL (#7, #8). COOL repairs and resells these products in the second-hand market (#7). COOL, though called as a scrap trader, is not a middleman that does only trading. COOL is authorized by the respective State Government and has VAT registration. COOL calls itself as a scrap merchant dealing with electrical and electronics products. There are thousands of scrap merchants like COOL all over the country. Some of them have VAT registration and some do not have VAT registration. These retailers do not sell to formal processors (#9). If there are product or components that cannot be repaired and reused, they are disassembled and sold to commodity traders or sold to Informal Processors.

Waste Pickers and Door-to-Door Collectors also sell their collection to scrap traders. This is evident from comments #4, #13, #16, #18, #19, #20. For example, Co-founder of RWM said:

"If it is dumped in a garbage bin, it still finds its way to the scrap trader...because, there are so many small rag pickers in our country who keep looking for these items. So, they [rag

pickers] take all these small things and they [e-waste/scrap/material] again come back to the scrap trader. So, ultimately...whichever way you dispose it...it finally comes to the scrap trader." – (#13).

Evidence from secondary sources corroborates that waste pickers sell to scrap traders (#29) and scrap traders are the first layer in the supply chain that collects from households and small-and-medium firms (#27).

P10.2 Definition of Scrap Trader is fluid

Zonal Manager (South) of AMO said regarding the reverse supply chain of customer returned products:

"After getting products from consumers, we prepare a quote for a list of products. We accept quotes from different vendors and choose the best vendor. The quote lists price of every product. It goes through our store, accountant, store manager, etc. All of them have to agree on the prices. One person cannot decide it. We have a strict process for that. The chosen vendor buys products from us by paying the price per product. This is vendor 1.", "This vendor 1 resells the products to vendor 2 and makes a margin. Small repairs, inspections will be done on the products and enters the second-hand market. Thus, vendor 2 also makes a margin. In some cases, the products will be sold at scrap value to vendor 3 [a scrap trader who deals only with scrap]. For example, damaged or broken products that cannot be repaired and sold in second-hand market. Vendor 3 also makes a margin by trading the scrap received. This is a billion dollar business. There are vendors for each category like paper, plastic, e-waste, etc." – (#11).

Based on this definition of AMO, COOL is Vendor 1 who also does the work of Vendor 2. But, COOL is not Vendor 3 i.e. COOL is not the firm who deals only with scrap or commodities. Thus, the definition of a scrap trader is fluid. Though they are popularly called as "scrap dealers", "scrap traders", "scrap vendors", "scrap merchants", etc. they engage in various operations across the reverse supply chain. This aspect is discussed in detail while evaluating Proposition 11.

Evaluation: Though support was found for this proposition (w.r.t Retailers), field evidence also revealed other stakeholders who sell e-waste to scrap traders (vide P10.1). We did not find evidence regarding Dealers selling to Scrap Traders. In light of these evidence, this proposition is revised as follows in Table 57.

Table 57: Evaluation of Proposition 10

Original proposition	*P10: Retailers and dealers sell e-waste only to scrap traders because they receive higher payment.*
Revised proposition	*P10: PCMs, Retailers, Waste Pickers, and Door-to-Door Collectors sell e-waste to Scrap Traders*

Proposition 11

P11: Scrap traders aggregate the collected e-waste up to an appropriate quantity and sell them to informal processors.

Evidence from the field (NVivo node: *P11*)

Scrap traders sell to informal processors (#1, #3, #6). For example, Proprietor of Delta revealed that during his stint in the informal economy, he purchased e-waste from scrap traders. Scrap Traders in remote parts of the country collect and aggregate all kinds of waste (including e-waste) and sell e-waste to informal processors located in major cities. But, as explained in P10.2, the definition of scrap trader is fluid. A scrap trader can also be an informal processor. For example, Informal Processor A is Joint Proprietor of a scrap metal trading firm JAS. This firm is recognized by the respective State Government and also has VAT registration. Informal Processor A purchases e-waste from Bulk Consumers and PCMs. Similarly, Informal Processor B is also a Proprietor of a scrap metal trading firm which is recognized by the respective State Government and also has VAT registration. Informal Processor B also purchases e-waste from Bulk Consumers and PCMs.

Evaluation: Though, overall support was found for this proposition, more nuances were obtained from field evidence. For example, it is not easy to distinguish in a clear way between scrap traders and informal processors (also discussed vide P10.2). To really understand this phenomenon, we need to understand the scrap metal supply chain. This is explained in Proposition 17. In light of these evidence, this proposition is revised as follows in Table 58.

Table 58: Evaluation of Proposition 11

Original proposition	*P11: Scrap traders aggregate the collected e-waste up to an appropriate quantity and sell them to informal processors.*
Revised proposition	*P11 (a): Scrap Traders collect and aggregate e-waste and sell them to Informal Processors.* *P11 (b): The definition of Scrap Traders and Informal Processors is fluid. Scrap Traders can play the role of Informal Processors and vice-versa.*

Proposition 12

P12: Manufacturers with take-back systems/collection systems sell the collected e-waste to formal processors; manufacturers do not own e-waste processing facilities.

Evidence from the field (NVivo node: *P12*)

P12.1 Manufacturers sell collected e-waste to formal processors

Manufacturers do not own e-waste processing facilities. They sell the collected e-waste (received from take-back/collection systems) to Formal Processors. This is evident from comments #1, #3, #5, #6, #8, #14, #15, #16, #18. For example, Deputy Director of Manufacturers' Association said regarding the IT hardware manufacturers:

"All the manufacturers have got a tie-up with one recycler", "whatever that they get…as part of their take-back system…as part of their collection channels, they give it to that recycler who definitely is an authorised recycler." – (#3).

Evidence from secondary sources revealed that an IT hardware manufacturer sold e-waste to formal processors after cannibalizing functional parts that can be used in their service centers (Subramanian, 2014).

P12.2 Manufacturers outsource collection and processing

For example, a MNC IT hardware manufacturer had tied-up with a Formal Processor for collecting and processing their products (#17). Interestingly, AIK (a MNC mobile phone manufacturer) has created a supply chain between Door-to-Door Collectors and Formal Processors (#7, #13) i.e. AIK has authorized Door-to-Door Collectors to collect e-waste, on their behalf, from Retail Consumers (including small home offices) and sell to a Formal Processor. Thus, field evidence reveals that Manufacturers outsource collection and processing to Formal Processors. Manufacturers also outsource collection to Door-to-Door Collectors who further sells the collected e-waste to Formal Processors for processing.

P12.3 Manufacturers do not refurbish and sell their products in second-hand market

Manufacturers do not prefer to refurbish their products and sell in the second-hand market with warranty (#4, #5). AIK had tried to make new phones using the raw material of used phones after collecting them from consumers (#4, #11). But, that initiative did not materialize in the country (#4, #11). In another case, a Manufacturer terminated its contract with the Formal Processor, after knowing that the Formal Processor was doing minor repair on the collected e-waste (i.e. consumer returns, out-of-warranty products) and selling them in the second-hand market (#6). Though LED sells the collected e-waste to a Formal Processor, they encourage the Formal Processor to refurbish or repair the products that can be made functional and sell in the second-hand market. But, LED does not give warranty for such refurbished products and this business outside the purview of LED (#8) i.e. refurbished products are not sold through the stores of LED (#8).

Evaluation: Overall support was found for this proposition (vide P12.1). However, field evidence revealed a more nuanced understanding (vide P12.2 and P12.3). In light of these evidence, this proposition is revised as follows in Table 59.

Table 59: Evaluation of Proposition 12

Original proposition	*P12: Manufacturers with take-back systems/collection systems sell the collected e-waste to formal processors; manufacturers do not own e-waste processing facilities.*
Revised proposition	*P12 (a): Manufacturers with take-back systems/collection systems sell the collected e-waste to Formal Processors; manufacturers do not own e-waste processing facility.* *P12 (b): Manufacturers may cannibalize functional parts that can be used in their service centers, before selling to Formal Processors.* *P12 (c): Manufacturers outsource collection and processing to Formal Processors.* *P12 (d): Manufacturers also outsource collection to Door-to-Door Collectors who further sells the collected e-waste to Formal Processors for processing.* *P12 (e): Manufacturers do not prefer to refurbish their products and sell in the second-hand market with warranty.*

Proposition 13(a)

> *P13 (a): Informal and formal processors have five options for processing e-waste: direct reuse, repairing, refurbishing, cannibalization, and recycling.*

Evidence from the field (NVivo node: *P13(a)*)

P13a.1 Direct reuse

Evidence for Direct Reuse was found from comments #2, #6, #7, #8, #9, #10, #26, #31, #34, #37, #53, #55, #73, #75, #77. For example, Founder of RTH said that the roughly 20% of the IT hardware purchased from IT firms (i.e. Bulk Consumers) are directly sold without any repair to appropriate dealers in the second-hand market (#31). Evidence from secondary sources corroborates this (#93, #96, #104, #122, #128).

P13a.2 Repairing-cum-refurbishing

Though repairing and refurbishing were hypothesized as separate processing operations, field evidence revealed that these two concepts were not labelled separately in the industry. The presence of repairing-cum-refurbishing is evident from comments #19, #26, #43, #44, #55, #65, #72. Though various stakeholders spoke about these concepts, they do not mean the theoretical definitions of "repair" and "refurbish". The words stakeholders use, connote making the product functional, and selling in the second-hand market. This confusion is noted in comments #11, #50, #52. For example, Business Development Manager of CIT said:

"There are scrap traders, who are basically refurbishers, and have been in this business for a long time. They have contacts with the corporates. Recently, scrap traders have also obtained license from pollution control boards. They can quote a high price for e-waste because they refurbish the product and sell in second-hand market." – (#50).

This does not mean the Scrap Traders do only "refurbishing" according to the theoretical definition. These Scrap Traders do repairing and some kind of refurbishing to make the products functional and sell in the second-hand market.

Evidence from secondary sources corroborates that repairing-cum-refurbishing is done (#92, #117, #140, #147, #150, #125, #127, #137). These secondary sources had reported repairing-cum-refurbishing operations of CFLs, washing machines, refrigerators, microwaves, mixies, air-conditioners, etc. For example, repairing-cum-refurbishing of CFLs was reported by Toxics Link (2014):

"There are also certain units where CFLs can be repaired. The filament and the connection is generally repaired and the glass top is obtained from big manufacturing companies which, due to their strict quality control, discard many glass tops due to minor defect." – (#92)

P13a.3 Cannibalization

This is evident from comments #16, #20, #26, #36, #43, #44, #55, #59, #63, #72. For example, Sustainability Head of AIK said: *"Most of the recyclers take out the components/parts and sell in the market…these parts will be used for repair works"* – (#59). Founder of EP said that the funnel and front glass of CRT (obtained from computers) are taken out and sold to a TV manufacturer (#63). The functional components/parts are taken out and sometimes refurbished or repaired before selling to service centers or manufacturers. For example, Co-founder of COMPOST said regarding cannibalization of CRTs from computers:

"…small electronic shop guys, the electronic shop where they repair your TVs and all that...if you have a computer, generally a cathode ray tube screen...it could be a computer or it could be a CRT screen...they test and see if it in a basic working condition...it is refurbished [if in a working condition] and it is sent to China where they make into a new TV", "Buffing is a form of cleaning the screen of scratches, any metallic or glass parts where they buff. It's a rotating machine, they buff it, so it becomes clean...no scratch and all that...then it is sent to China. In China, it is again refurbished into a TV. From there it is sold to different countries...Mostly third world economies." – (#29).

Evidence from secondary sources corroborates this (#85, #87, #92, #93, #94, #97, #99, #104, #119, #120, #121, #122, #123, #124, #125, #129, #130, #140).

P13a.4 Disassembly into commodities

This is evident from comments #1, #3, #4, #6, #7, #8, #9, #10, #12, #13, #14, #20, #21, #23, #24, #26, #27, #28, #29, #30, #31, #33, #34, #35, #42, #48, #51, #55, #57, #60, #61, #63, #66, #68, #69, #71, #72, #75, #81. For example, Consultant X described what an e-waste processor does. Though they are popularly called e-waste recyclers, they do not "recycle" in the theoretical sense. Consultant X said:

"At the dismantler level, they will dismantle and then they will keep all plastics separate, copper separate, wires and all that separate, sometimes they even remove the sheathing and give only the copper, steel separate, like that component wise they will segregate it…and then give it to the this one like glass to a glass recycler, plastic to a plastic recycler, it's not like a total e-waste recycler you can't call them…that is another wrong conception which is also there…because, where do you end up? you will end with a plastic recycler, you will end up with an glass recycler, you will end up with a steel recycler, copper recycler", "the whole processing is nothing but segregation…you need to identify what has what value and you will segregate it…that's all is the technology." – (#12, #14).

The PCBs are segregated, aggregated, and sold to respective buyers (#3, #35). In some cases, PCBs are further disassembled (#10, #39). For example, Informal Processor B said:

"I do the collection of PCBs here [pointing to PCBs in the shop]...after these people do dismantling, segregation, I collect the PCBs....what I do after collecting...I separate them into mother boards, IC boards...they are packed separately...then, send to separate people...I sell to them at a higher price." – (#10).

Evidence from secondary sources corroborates that products are disassembled into commodities (#86, #87, #89, #90, #91, #92, #93, #99, #100, #104, #105, #106, #107, #109, #110, #116, #118, #119, #121, #122, #123, #124, #125, #128, #130, #134, #136, #140, #141, #142, #144, #148, #149, #150).

P13a.5 Metal recovery

This involves recovering or extracting metal like gold, silver, copper, platinum, palladium, etc. from electronic components (ex: gold coated pins contained in PCBs) through chemical treatment. This is evident from comments #24, #27, #38, #47, #61, #63, #67, #71, #72, #78.

During a stakeholders' meeting, an informal-turned-formal processor said that his firm recovers (or extracts) silver from server boxes, X-ray sheets, keyboard sheets and recovers platinum, silver, and molybdenum from heavy electrical machinery (#67).

Data from secondary sources corroborates this (#87, #89, #90, #104, #105, #111, #114, #120, #123, #131, #136, #138, #145, #148, #149).

Evaluation: Though overall support was found for this proposition, field evidence revealed certain nuances. For example, repairing and refurbishing operations were not clearly separated in the industry (vide P13a.2); recycling operation was separated as disassembly into commodities and metal recovery (vide P13.a4 and P13.a5). As hypothesized, we did not find evidence for the presence of remanufacturing. In light of these evidence, this proposition is revised as follows in Table 60.

Table 60: Evaluation of Proposition 13(a)

Original proposition	*P13 (a): Informal and Formal Processors have five options for processing e-waste: direct reuse, repairing, refurbishing, cannibalization, and recycling.*
Revised proposition	*P13 (a): Informal and formal processors have five options for processing e-waste: direct reuse, repairing-cum-refurbishing, cannibalization, disassembly into commodities, and metal recovery.*

Proposition 13(b)

P13 (b): Functional products having high demand in second-hand market are directly reused and sold to channels in second-hand market; functional products having low demand in second-hand market are cannibalized or recycled.

Evidence from the field (NVivo node: *P13(b)*)

P13b.1 Functional products having demand in second-hand market are directly reused

This means that such products are directly sold to dealers in second-hand market or the processor himself sells directly in the second-hand market. This is evident from comments #1, #2, #3, #4, #8, #13, #18, #19, #21, #22, #25, #26, #27, #31, #34, #35, #36, #38, #39, #40, #55. For example, Informal Processor A said:

"If 100% material is worth reusing, it is reused...if it is reused, who will get benefited? See...I have money...you also have money...you can afford to buy CPU, monitor for your kids by paying Rs. 40-50,000...those kids will use it and learn...now, there are these small small people with a salary of Rs.10,000, Rs.15,000...those people need to spend that money for their living expenses...if those people get material through second-sale, their kids are benefited...doing this will improve our country...so, for that purpose, second-sale is good...only keep those material in second-sale which is 100% running [functional products]" – (#1).

Typically, whenever a product is functional, it always has some demand in second-hand market (#23). Founder of RTH spoke about the large demand for computers run on Pentium processors, in the second-hand market in Tier-2, Tier-3 cities. (#19). Sometimes, Formal Processors cannot directly reuse the functional product and sell to dealers in second-hand market due to prevailing contracts with bulk consumers or manufacturers (#16, #17, #20). For example, Co-founders of AMY said:

"We do not repair and resale material…we do not do that. You have given us this letter from IIM…now, if you find this same latter with a pani puri seller in the roadside, how will you feel? You will feel bad. This is what companies will feel if we resell the material. There is a lot of IP, patents in these material…we have to dismantle it…we will not repair and resell in the market. Companies can give complaint against us if we resell their material. We destroy the hard disks,

drill holes in them….so that it cannot be reused in the second-hand market…of course, reselling hard disks will fetch you more profit…but, we don't do it…we dismantle all material." – (#17).

Evidence from secondary sources corroborates this (#42, #44, #47).

P13b.2 Functional products having low demand in second-hand market are disassembled into commodities

This is evident from comments #4, #10, #12, #15, #22. For example, Proprietor of COOL said functional black-and-white TV does not have any demand in the second-hand market and has to be disassembled into commodities. It is to be noted that, for certain products disassembly into commodities may not be profitable for the processor (negative salvage value). For example, Proprietor of COOL said regarding disassembling (popularly known as "scrapping" in this industry) a black-and-white TV:

"If we scrap TV waste, we have to incur heavy loss...we will not get anything out of it ...you will hardly get Rs. 500 from a TV...with great difficulty, you can make Rs. 500 if there is anybody who will buy cabinets from you...if there is nobody to buy cabinets, you will Rs. 200 or Rs. 300...take it as Rs. 300...for scrapping one TV." – (#12).

Evaluation: Partial support was found for this proposition. Functional products have high demand in second-hand market are directly reused and this is moderated by contracts with Bulk Consumers (vide P13b.1). Contrary to the hypothesized proposition, field evidence revealed that Functional products having low demand in second-hand market are disassembled into commodities (vide P13b.2). In light of these evidence, this proposition is revised as follows in Table 61.

Table 61: Evaluation of Proposition 13(b)

Original proposition	*P13 (b): Functional products having high demand in second-hand market are directly reused and sold to channels in second-hand market; functional products having low demand in second-hand market are cannibalised or recycled.*
Revised proposition	*P13 (b1): Functional products having demand in second-hand market are directly reused (i.e. sold in the second-hand market); But, this is moderated by prevailing contracts with Bulk Consumers*

	P13 (b2): Functional products having low demand in second-hand market are disassembled into commodities

Proposition 13(c)

P13 (c): Non-functional products with high design modularity, high demand in second-hand market, and whose functionality can be restored are repaired or refurbished.

Evidence from the field (NVivo node: *P13(c)*)

While evaluating this proposition, concept of "design modularity" has not been included due to lack of evidence.

Non-functional products having high demand in second-hand market and whose functionality can be restored are repaired-cum-refurbished. This is revealed from comments #7, #8; and comments from Node P13(b): #7, #22, #23, #25, #38. For example, Founder of RTH said restoring functionality of non-functional products that have demand in second-hand market (ex: printers, laptops, desktops, monitors):

"We have testing center...if you give 100 PCs to testing center, he will check every piece...whether it is running or not running...if it is not running, can something be done and make it work by changing parts and other things...because, we want to generate revenue...so, we will put some parts and some things...for example, if its mother board is damaged, or if the damage is in the socket, or its hard drive is damaged, or if its RAM is not working..." – (#7).

Proprietor of Delta narrated his experience of purchasing defective mobile phones from a reputed Manufacturer. He said, this Manufacturer knew that processors like him would repair-cum-refurbish and sell their phone in the second-hand market. Delta does repairing-cum-refurbishing on those phones, makes them functional, and sell them to dealers in the electronic markets in Burma Bazaar, National Market, etc. These dealers package the phones in duplicate boxes (having the name of the Manufacturer's brand) and sell at prices much below the price of the new phone.

Evidence from secondary sources corroborates this (comments #11, #12, #13, #17, #19, #21, #27).

Evaluation: Support for found for this proposition (after taking out the concept of design modularity). This proposition is revised as follows in Table 62.

Table 62: Evaluation of Proposition 13(c)

Original proposition	*P13 (c): Non-functional products with high design modularity, high demand in second-hand market, and whose functionality can be restored are repaired or refurbished.*
Revised proposition	*P13 (c): Non-functional products having high demand in second-hand market and whose functionality can be restored are repaired-cum-refurbished.*

Proposition 13(d)

P13 (d): Repairing is preferred for low functionality loss and refurbishing is preferred for high functionality loss.

Evaluation: We did not obtain evidence from primary and secondary sources to evaluate this proposition. This could be because both these concepts are used interchangeably in the industry, as pointed out while evaluating one of the previous propositions.

Proposition 13(e)

P13 (e): Non-functional products with high design modularity and whose functionality cannot be restored are cannibalised for using its parts as spares or inputs to other products.

Evidence from the field (NVivo node: *P13(e)*)

While evaluating this proposition, concept of "design modularity" has not been included due to lack of evidence.

It was found that non-functional products whose functionality cannot be restored are cannibalized. This is evident from comments #2, #5, #6. For example, Proprietor of COOL said about what he does to non-functional products*:*

"Killing it alive...totally, we are making postmortem...after doing postmortem, we take out parts...like this compressor, motor, fan [pointing to compressors, motors kept in his shop]...after taking them out, we will keep it here...if any customer, dealer, or mechanic comes, we sell to them for Rs. 100 or Rs. 200." – (#2).

Parts cannibalized are sold only if they are worth selling i.e. if they are functional and have demand in the second-hand market (#2). Co-founder of RWM had an interesting perspective on cannibalization. He said that cannibalization is decreasing these days due to technological obsolescence:

"The speed of technological obsolescence is so fast that, I really can't use any spares from the old machine, they don't fit into new ones. It used to be a very big stream earlier...now, it is diminishing and I think, more or less, it will be gone." – (#5).

For some products, cannibalization is not done due to prevailing contracts with the Bulk Consumers (#4). For example, though hard disk drives have demand in second-hand market, they are destroyed (by the Formal Processor) within the premises of Bulk Consumers. Otherwise, if such disk drives gets into the market, there is a potential for data leakage.

Evidence from secondary sources corroborates that cannibalization exists (#13).

Evaluation: Partial support was found for this proposition (after taking the concept of design modulariy). Field evidence also revealed a more nuanced understanding of this phenomenon (ex: prevailing contracts with Bulk Consumers, role of technological obsolescence). In light of these evidence, this proposition is revised as follows in Table 63.

Table 63: Evaluation of Proposition 13(e)

Original proposition	*P13 (e): Non-functional products with high design modularity and whose functionality cannot be restored are cannibalised for using its parts as spares or inputs to other products.*
Revised proposition	*P13 (e1): Non-functional products whose functionality cannot be restored are cannibalized.* *P13 (e2): Functional products with low-demand in second-hand market or due to prevailing contracts with Bulk Consumers are cannibalized.* *P13 (e3): High rate of technological obsolescence leads to low level of cannibalization*

Proposition 13(f)

P13 (f): Functional products with low design modularity and low demand in second-hand market are recycled; functional products with high design modularity and low demand in second-hand market are cannibalised.

Proposition 13(g)

P13 (g): Non-functional products with low design modularity and high demand in second-hand market are recycled.

Evidence from the field (NVivo node: *P13(f) and P13(g)*)

While evaluating this proposition, concept of "design modularity" has not been included due to lack of evidence.

P13f Functional products with low demand in second-hand market are disassembled into commodities

This is evident from #4, #8. For example, Business Development Executive of a formal processor said regarding disassembly of a computer (that cannot be sold in the second-hand market):

"You've taken the computer, it is not working or it is not saleable in the market...whatever iron is there, iron is taken out and sold to iron scrap fellow. And PCB is taken out, it goes to the PCB melter...that PCB fellow will burn it, melt it and take the copper out of it...copper fellow will be there...capacitors and all that will go to aluminium fellow. So, segmentation will take place there. Glass will go to glass [glass fellow]." – (#4).

Data from secondary sources corroborates this (#44).

P13g Non-functional products with low design modularity and high demand in second-hand market are recycled

There is evidence that supports that products are disassembled into commodities and metal recovery is done from such disassembled parts (#10, #23, #24, #26). But, we did not obtain specific evidence regarding the product type (i.e. functionality, demand in second-hand market, etc.). These ideas are evident from comments #10, #11, #16, #21. Hence, there is lack of evidence to evaluate P13(g).

Evaluation: It was found (vide P13(e2)) that Functional products with low-demand in second-hand market or due to prevailing contracts with Bulk Consumers are cannibalized. While evaluating P13 (f), it was found that Functional products with low demand in second-hand market are disassembled into commodities (vide P13f). Both these findings are complementary and adds value to our understanding of the phenomenon. Combining both these, we can say that Functional products with low demand in second-hand market are disassembled into commodities or cannibalized based on the most profitable option for the Processor. For example, even though a product may not have demand in the second-hand market, its parts would have demand for manufacturing another product. If its parts also does not have any market demand, then the product is disassembled into commodities. In light of these evidence, this proposition is revised as follows in Table 64.

Table 64: Evaluation of Proposition 13(f) and 13(g)

Original proposition	*P13 (f): Functional products with low design modularity and low demand in second-hand market are recycled; functional products with high design modularity and low demand in second-hand market are cannibalised.* *P13 (g): Non-functional products with low design modularity and high demand in second-hand market are recycled.*
Revised proposition	*P13 (f1): Functional products with low demand in second-hand market are disassembled into commodities if its parts does not have demand in the second-hand market.* *P13 (f2): Functional products with low demand in second-hand market are cannibalized, if its parts have demand in the second-hand market.*

Proposition 13(h)

P13 (h): Unprocessed portion of products is disposed in landfills.

Evidence from the field (NVivo node: *P13(h)*)

P13h.1 Composition of non-recyclable materials

Non-recyclable materials include the following: tube inside the CRT monitor (#1); cable fibre and glass fibre (#1, #12 #20); CFLs, bulbs, and tube lights (#2, #7, #12, #24); epoxy from circuit boards (#15, #20); acid and sludge during metal recovery process (#8, #12); rubber parts (#12); waste oil (#12); thermocol (#12); carbon black, ink of cartridges (#20). For example, Founder of RTH said:

"See, if you take a PC...and the company is giving to you in a box...it [thermocol] comes automatically...so, you need to dispose that thing...you cannot keep it with you...you cannot make money from it anyway...ultimately, you need to dispose that" – (#12).

It is interesting to find that materials that were getting recycled earlier has become non-recyclable due to lack of a market. Informal Processor B said about lack of market for recycling glass and fibre i.e. glass from picture tube of monitors, fibre material (a combination of plastics) that can be found in printers and other products (#4). He said regarding glass:

"There is a glass tube, picture tube...now, what is happening to these? They are not getting recycled...these were getting recycled before...now, they are not getting recycled. All those small companies that were recycling these things have shut down...now, nobody is using glass...picture tube, broken glasses are being put in the dustbin...someone may pick it up from the dustbin...else, nothing happens.", "in Nayandahalli, there were around 5 to 10 small factories and companies who used to buy glass...now, they are closed...companies are no more there. Now, totally the glass is not reused...is totally a waste, now...it is being dumped just like that...it is not getting recycled.", "you see wherever you want, you will not find glass recyclers. Before how it was...it used to get sold at 5 paisa, 10 paisa, 20 paisa per kg...now, there are no buyers." – (#4).

He also said that he used to sell fibre to plastic recycling factories at low price and those recyclers were making granules from it (#4). But, Government (i.e. SPCB) had closed down these small factories (possibly due to their high polluting activities) (#4)[36].

P13h.2 Informal processors dispose non-recyclable material in the open

This is evident from comments #1, #3, #4, #10, #15, #16, #18. For example, Informal Processor B said:

"Picture tube of monitors. These will be taken and dumped in corporation bins...they will take something, leave something else...they will take it and dump it in some other place...so, it is getting dumped...it is not getting reused or recycled." – (#4).

P13h.3 Formal processors dispose non-recyclable material to TSDFs by paying them money.

This is evident from comments #1, #3, #7, #8, #11, #12, #15, #16, #17, #18, #20, #23, #26, #27, #28, #34. For example, Informal Processor A (who sometimes used the facility of Formal Processors) said:

"Whatever is non-recyclable, we used to throw it wherever we wanted to...but, now it is safely stored in a storage area...and when it reaches 500 kg, 1 tonne, we give to Ramky by raising invoice and filling Form 13...they [Ramky] take Rs. 20 or Rs. 30 per kg from us." – (#3).

TSDF can be a pure-play incinerator who burns the material, converts to ash, and sends to a firm that does scientific landfill (#22, #30). TSDF can also be an incinerator-cum-scientific land filler which does both incineration and scientific landfilling. For example, Proprietor of IMT (a pure play incinerator) said:

"I need to burn properly and give to him [scientific landfiller]...so, he will put it in that land...then, again this is process...again, he need to blend, put some other sorts of mixtures and all.", "what they do is...they have their...landfill in the sense, it's not digging the land and

[36] In essence, this says that Governmet intervention by closing by commodity recyclers, destroyed 'liquidity' in the market for waste i.e. this created 'frictions' in the market for e-waste processors.

putting everything and burying, closing the land. It's digging of 30 feet down...putting an FRP coat, then putting the waste, then again an FRP closure, then putting some mud, then cement, then again some next layer...that is the process." – (#22).

Evaluation: Partial support was found for this proposition. Field evidence revealed a more nuances understanding of this phenomenon (vide P13h.1, P13h.2, P13h.3). In light of these evidence, this proposition is revised as follows in Table 65.

Table 65: Evaluation of Proposition 13(h)

Original proposition	*P13 (h): Unprocessed portion of products is disposed in landfills.*
Revised proposition	*P13 (h1): Informal processors dispose non-recyclable material in the open, probably joining along with municipal solid waste.* *P13 (h2): Formal processors dispose non-recyclable material to TSDFs by paying them money.* *P13 (h3): Certain materials can be recycled, if there are appropriate markets. Those materials that does not have a market ends up in landfills or with TSDF.*

Proposition 13(i)

P13 (i): Influence of design modularity on processing operations

Propositions 13(c), (e), (f), (g) had the concept of design modularity. For the purpose of evaluating those propositions, this concept was taken out. The influence of this concept on processing operations was evaluated separately. Proposition 13(i) was not part of the initial list of propositions developed before fieldwork.

Evidence from the field (NVivo node: *P13(i)*)

P13i.1 There is no influence of design modularity

Evidence from some Processors reveal that there is no influence of design modularity on processing operations. This is evident from comments #1, #2, #4, #5, #9, #10, #11, #14, #17, #18, #20. For example, Co-founders of AMY said:

"We have not found any particular brands to be easy to disassemble…or brands that fetch more value etc. For us, all brands are alike…we can dismantle anything and everything easily…be it HP or Apple or Lenovo….everything is the same for us." – (#10).

P13i.2 There is some influence of design modularity

Evidence from some Processors reveal that products with integral designs have better scrap value i.e. commodity value. This is evident from comments #3, #12, #23. For example, Informal Processor B said products from Sun Microsystems and Apple fetch better commodity value when compared to products from HP, IBM, Dell, etc. This is because, products from Sun and Apple have high quality materials (ex: high quality plastics, PCBs with good metal content, etc.). Joint Proprietor of Gamma said:

"Look at this Apple computer [pointing to one lying on the shop floor]…the plastic casing of Apple computers are heavy and of good quality…one can get a good price for it in the market…but, the monitor of Apple computers will not get sold anywhere…it will have to be

broken and dumped…but, the computer monitor of any other company can be sold to a TV manufacturer…Why? Apple's monitor do not fit into the standard TV casing." – (#23).

Evidence from some processors revealed that though they face difficulty in disassembling products with integral designs, it is not a major problem for them (#3, #12, #23). For example, Informal Processor B said:

"Yes...it is little difficult...they use completely different screws...they have different technology...but, their material is good, there are some problems in dismantling them.", "we can do it [dismantle] finally...there is no material that cannot be dismantled in India...you go to informal, take any material with any problem...within 10 mins it will be broken and torn apart into pieces...there is no problem" – (#3).

Co-founder of RWM said that normal products will have an open PCB, but Apple's PCB is not completely open (#12). Apple uses some material to cover the circuit and the material solidifies over there (#12). He said: *"You can't see which PCB, which circuit, which chip is used, nothing you can see."* – (#12). And, removing this material is difficult. (#12). A recycling enthusiast concurred with this:

"Some manufacturers protect their IP by sealing the entire printed circuit board by epoxy. If you look at Apple's products…their boards are not visible, it is covered/sealed by epoxy coating…only if you remove this coating, you can see what is inside the board…if you try to remove the coating, the board will break. So, even if the issue is with respect to one small component or IC in the board, the entire board has to be replaced. So, the entire old board gets wasted." – (#19).

Evaluation: Overall, support was found for this proposition (vide P13i.2). The logic explained in P13i.2 is strong and supports the proposition that there is some influence of this design modularity on processing operations. In light of this evidence, this proposition is revised as follows in Table 66.

Table 66: Evaluation of Proposition 13(i)

Original proposition	*P13 (i): Influence of design modularity on processing operations*
Revised proposition	*P13 (i1): Products with integral designs are difficult to repair-cum-refurbish, cannibalize, and are disassembled into commodities.* *P13 (i2): Products with integral designs are difficult to disassemble when compared to products with modular designs.* *P13 (i3): Products with integral designs have higher commodity value when compared to products with modular designs.*

Proposition 14(a)

P14 (a): A single processor (informal or formal) does all the five processing operations: direct reuse, repairing, refurbishing, cannibalisation, and recycling.

Evidence from the field (NVivo node: *P14(a)*)

Some processors are involved in doing multiple (more than one) processing operations, but not all the five. This is revealed from comments #1, #2, #3, #4, #7, #5. For example, Mash does only direct reuse, repair-cum-refurbishing, and cannibalization (#1). This processor does not do metal recovery and disassembly into commodities. The formal processor EP is majorly involved in disassembly into commodities, but also does recovery of gold, silver, and copper (#2). Founder of RTH said that all processing operations cannot be done by a single Processor:

"You cannot do everything in one place...you can do some things in one place...some other things in another place...everything cannot be done in one place." – (#3).

Processors are focussed majorly on one or two processing operations (#4). In India, 100% metal recovery does not happen (#3, #4). The metal coated components from PCBs are sold to Precious Metal Refiners abroad for metal recovery. Processors like EP, recover only few metals like gold, silver, copper which are relatively easy and less costly to extract. Co-founder of RWM said regarding the economics of metal recovery/extraction:

"Extractable metals...if you look at it...they are copper, aluminium, tin, gold, silver, palladium, iron...these 8 metals are easily and, not I would say easily, but these 8 metals are available in size-able quantities. Platinum, very rare...you won't get it in that much quantities. Nickel, is available in size-able quantity...but, process of recovery is terrible...so, investment cost of that doesn't break-even...so, nickel is usually not recovered. Mercury is there in traces, and the plant required for recovery of mercury is horribly expensive...so, it's not recovered...it doesn't break-even. So, those are the dependencies...7-8 metals, it's easy to...easy and possible to extract them. E-waste has got more than 100 metals now...there are different different types of metals, you can't really extract everything. Mercury is available in such small traces that process itself discharge that [i.e. if you set-up a process of extract mercury, the process itself

is such that, those small traces of mercury is discharged during the process and we will not get mercury at the end of the process].” – (#4).

Evidence from secondary sources corroborates that a single processor does not do all the five processing operations (for example, Inagaki (2008)).

Evaluation: Support was not found for this proposition, based on field evidence. However, a more nuanced understanding of this phenomenon was obtained. Hence, this proposition is revised as follows in Table 67.

Table 67: Evaluation of Proposition 14(a)

Original proposition	*P14 (a): A single processor (informal or formal) does all the five processing operations: direct reuse, repairing, refurbishing, cannibalization, and recycling.*
Revised proposition	*P14 (a1): A single processor (informal or formal) does not do all the five processing operations: direct reuse, repairing-cum-refurbishing, cannibalization, disassembling into commodities, and metal recovery.* *P14 (a2): Processors focus majorly on one or two processing operations* *P14 (a3): Processors involved in metal recovery, recovers only the easy-to-extract metals; Metal recovery of difficult-to-extract metals are done by Precious Metal Refiners outside the country.*

Proposition 14(b)

P14 (b): Processors (informal or formal) do selective recycling operations.

Evidence from the field (NVivo node: *P14(b)*)

Evidence from various stakeholders reveal that processors do selective recycling operations. This is evident from comments #1, #2, #3, #4, #5, #6, #7, #8, #9, #10, #11, #12, #13, #15, #16, #17. For example, Consultant X said:

"At the dismantler level they will dismantle and then they will keep all plastics separate, copper separate, wires and all that separate, sometimes they even remove the sheathing and give only the copper, steel separate, like that component wise they will segregate it…and then give it to the this one like glass to a glass recycler, plastic to a plastic recycler, it's not like a total e-waste recycler you can't call them…that is another wrong conception which is also there…because, where do you end up? you will end with a plastic recycler, you will end up with an glass recycler, you will end up with a steel recycler, copper recycler." – (#3).

But, RTH has recently installed furnaces to melt scrap copper, aluminium, brass (from e-waste) to be converted to ingots (#8). Evidence from secondary sources reveal that Attero Recyclers have set-up a plastic-to-fuel conversion plant for recycling non-recyclable plastic from e-waste. But, these evidence are not contrary to the proposition. Co-founder of RWM said about different levels of e-waste processing i.e. L1, L2, L3 and Processors in India does not do L3 level of e-waste processing:

"L1 is basic dismantling, L2 is about taking out certain metals…there is an advanced stage called L3 level…currently, we do not make machinery for L3 processing. It will cost crores for L3 processing. It is being done in Europe, Japan, Singapore, Malaysia. Our machinery for L2 processing will cost around 35 lakhs to 80 lakhs. Though many recyclers in India say that they do L3 processing, actually they do not. Everything is being exported for L3 processing. EP is doing some work in L3 processing when compared to other recyclers in India…but, they also export boards for final level processing." – (#15).

Easy-to-extract and difficult-to-extract metals fall under L2 and L3 levels, respectively.

Evaluation: Support was found for this proposition, from field evidence. Thus, it was found that Processors do not do metal recovery to the fullest extent possible. Also, the disassembled commodities are sold to respective scrap commodity traders or scrap commodity recyclers. Though few Processors have vertically integrated (ex: RTH, Attero, etc.), they still do not cover the entire spectrum of recycling all commodities. This proposition is revised as follows in Table 68.

Table 68: Evaluation of Proposition 14(b)

Original proposition	*P14 (b): Processors (informal or formal) do selective recycling operations.*
Revised proposition	*P14 (b1): Processors (Informal or Formal) do selective metal recovery.* *P14 (b2): Processors (Informal or Formal) do not involve in end-to-end commodities recycling.*

Proposition 14(c)

P14 (c): Informal processors incur lower costs and produces lower quality output when compared to formal processors.

Evidence from the field (NVivo node: *P14(c)*)

P14c.1 Informal Processors incur lower costs when compared to Formal Processors

This is evident from comments #1, #3, #6, #12, #13, #14. This is also summarized in Table 69. Some quotes from respondents which best illustrates this are provided below.

"They [Informal] don't spend for energy, electricity, because they just hook it from the thing [drawing electricity illegally]…and labour is cheap, they don't need to go and get license and they don't need to spend money for all that…so, typically they don't have any cost as such…they do it in their own house and in the same set-up and…whereas when you are formalised, you need to spend for all that. Right from getting the license, getting a building, machinery, electricity, and some small furniture…they have to spend money." – Consultant X (#6)

"Informal sector, you don't pay much cost for space...because, space is also informally acquired...labour is underpaid....usually, they have this child labour and woman labour and underpaid labour. There is no cost of pollution control equipment. There is no cost of machinery...because, it's either open burning or open acid leaching, all that you need is a cement tank or a bucket...with acid or kerosene...nothing else. So, for them...the operating cost is very very low." – Co-founder of RWM (#14).

Table 69: Cost components of Informal and Formal Processors

Cost components of Informal Processor	Cost components of Formal Processor
• Minimal facility (own house or in the neighbourhood) • Hire-and-fire labour (daily wages)	• Facility (including land and building in an industrial area) • Pollution abatement technology • Electricity to run the pollution abatement technology • Monthly salary for employees

Evidence from secondary sources corroborates this (#26, #29, #34).

P14c.2 Informal Processors produce lower quality output when compared to Formal Processors

This is evident from comments #4, #5, #12, #14, #15, #16, #21. For example, Consultant X said that formal processor can recover more quantity of metals (i.e. higher yield) when compared to informal (#4, #5). During a stakeholders' meeting, Consultant X said:

"Formal recyclers can pay Rs. X to purchase e-waste and 95% recovery is possible due to superior technology/equipment. Informal recyclers can pay Rs. 2X to purchase e-waste and only 30% recovery is possible due to inferior technology/equipment." – (#21).

Co-founder of RWM said that yield and purity of metals are better when done by formal processors due to additional efficiency given the equipment or machinery. This idea was illustrated by him using an example of extracting copper from wires:

"Just talk on wires...in the informal sector, they burn wires...when you burn wire, what happens is, the plastic i.e. the external PVC, is reduced to tar...and the remaining copper is inside that tar. So, what you get is a bulk of tar and copper put together and then you clean that copper manually, the final output is not very clean", "in a formal sector, we don't burn copper, we put them through a grinding machine...we de-sleeve it and then we will extract the copper in its original form. So, without heating it, we are getting the copper in its original form. So, the losses are minimal, the output is richer...you can actually see that rich shine of copper. It fetches you more money" – (#14).

Data from secondary sources corroborates this (#28, #34, #35, #37, #40). For example, the website of RWM notes that yield and purity are low when done by an informal processor: *"The total yield of such processes cannot go beyond 30-40%"* (#34); when done by a formal processor: *"the yield is increased to as high as 98% . Also the purity of the metals is much higher fetching higher returns"* – (#35). In a similar vein, Business Development Manager of Earth Sense Recyclers said informal processors achieve a yield of 35-40% while formal processors achieve a yield of 75-90% during metal recovery operation (Bhatia & Aravind, 2014).

Howerver, there is a conflicting evidence here. Informal Processors' have the following unique skills in e-waste processing: tacit knowledge (explained in Theme 1 in Chapter 5) and manual disassembly (explained in Theme 4 in Chapter 5). The presence of these skills in Informal Processors leads to higher yield and purity of the output. For example, Business Development Manager of Epsilon claimed that informal processors recover higher yield (more than 90%) of precious metals when compared to precious metal refiners in Germany who realizes a yield of 60-70%. He had observed this during his recent visit to precious metal refiners in Germany (this explanation from the Business Development Manager of Epsilon, is from Theme 1 in Chapter 5).

Hence, there is no conclusive evidence to claim that Informal Processors produce lower yield and purity during metal recovery, when compared to Formal Processors.

Evaluation: Support was found for this proposition, based on field evidence. However, this proposition needs to be more precise to capture the concepts of yield and purity of metals. In light of these evidence, this proposition is revised as follows in Table 70.

Table 70: Evaluation of Proposition 14(c)

Original proposition	*P14 (c): Informal processors incur lower costs and produces lower quality output when compared to formal processors.*
Revised proposition	*P14 (c1): Informal Processors incur lower costs when compared to Formal Processors.* *P14 (c2): There is no conclusive evidence to claim that Informal Processors produce lower yield and purity during metal recovery operation, when compared to Formal Processors.*

Proposition 15

P15: Negative externalities are created by informal processors during the five processing operations on all types of products and landfilling; formal processors do not create negative externalities during the five processing operations on all types of products and landfilling.

Evidence from the field (NVivo node: *P15*)

P15.1 Formal processors minimize occupational diseases during disassembly, metal recovery

This is evident from comments #2, #13, #18, #21, #32, #35, #36, #41. For example, Co-founder of RWM spoke about the importance of dealing with dust while processing e-waste:

"You need to have effective dust collection, because the dust is really bad. We have ourselves experienced it", "if you hold the PCB in your hand for any number of days or months, you don't have any problem...but, the PCB dust is extremely itchy. The dust of a PCB...and if it flies in the air somehow, and if it comes in contact with your skin, you will have a skin irritation for three days", "So, that dust is extremely toxic...3 days it will itch and you can't even...even if you take a bath or something, you can't scrub it...the more you scrub, the more it will itch. Because, those particles are really fine and they go inside your skin. So, that's very dangerous." – (#18).

Due to these reasons, e-waste needs to be processed in a facility that has pneumatic equipment or closed chambers for collecting dust (#18). Formal processing ensures that e-waste processing happening in such kind of dust-free facilities (#18).

P15.2 Informal processors create occupational diseases during disassembly, metal recovery

This is evident from comments #13, #14, #15, #28, #29, #41. During field research, directly observation was done at the facility of Informal Processor B:

"The work was being done on the road…just outside the shop. The workers worked using bare hands without any gloves, masks, caps, or goggles. The workers were inhaling the dust…two

types of dust were there. One is from the outer surface of products…another is the dust trapped inside products. For example, when workers were taking out parts from the servers, they were wiping off the dust that had got into their nose. I[37] *also inhaled the dust as I was standing very close to them to see their operations. The trapped dust that comes out from the inside of products is more intense and thick, than the dust from outer surface. I felt intense irritation on nose and throat even though I was just standing there."* – (#28).

Evidence from secondary sources corroborates this (comments #48, #49, #50, #53, #54, #56, #59, #62, #64, #66, #67, #68, #69, #72, #74, #77).

P15.3 Formal processors minimize negative environmental externalities during disassembly, metal recovery

This is evident from comments #27, #32, #35, #36, #37. The dust collectors used during disassembly and metal recovery, collects the dust/fumes and does not release it to the outside environment (#27).

P15.4 Informal processors create negative environmental externalities during disassembly, metal recovery

This is evident from comments #3, #10, #16, #23, #24, #28, #29, #30, #37. The dust and fumes emitted at the facility of informal processors gets into the outside environment, thereby affecting people who reside in the neighbourhood.

Evidence from secondary sources corroborates this (#46, #49, #52, #53, #59, #61, #62, #63, #71, #72, #73, #74, #76, #77).

P15.5 Formal processors minimize negative environmental externalities during landfilling

This is evident from comments #2, #13, #17, #19, #20. The formal processors send the leftovers and by-products to hazardous waste incinerators or TSDFs. Evidence from secondary sources corroborates this (#65).

[37] 'I' denotes the doctoral student.

P15.6 Informal processors create negative environmental externalities during landfilling

This is evident from comments #1, #4, #13, #17, #19, #20. Informal Processors cherry-pick what is important to them and dispose the rest in public spaces like roadsides, municipal dustbins, etc. For example, Founder of Bravo said:

"So, this is typically what happens...you've got a basket with so many different things and informal person will take what interests him most in terms of economic value...and he will decide a price for that. He doesn't have to recycle your charger...so, there is no costs for him to chuck it out. A formal person will probably have to recycle that and make sure he will spend that money for recycling." – (#19).

Evidence from secondary sources corroborates this (#46, #47, #65, #70, #71, #72).

P15.7 Other stakeholders also create negative environmental externalities

Apart from Informal and Formal Processors, other stakeholders like Bulk Consumers and Commodity Recyclers (ex: plastic recyclers, copper recyclers, glass recyclers, etc.) also create negative environmental externalities. Some Bulk Consumers dump all their electrical and electronic scrap in the open (#9). Sometimes, batteries are buried in the ground and this may lead to leakage of hazardous metals and acids. Plastic recyclers and metal recyclers who operate in the informal economy also create negative environmental externalities. These are evident from comments #11, #16, #33, #42, #79, #84. For example, Founder of RTH said:

"If you are making ingots, or doing copper recycling or doing brass recycling...if you don't have proper pollution equipments...i.e. if you don't have scrubber...ultimately, the output will go to the air and contaminates the air." – (#16).

During fieldwork, the following observation was made:

"Though all the plastic recyclers in ABChalli [disguised name of the place] are registered, they are create pollution. The workers do not use any protective equipment…the sludge is left untreated…etc. Some of them are registered as manufacturers for making plastic products from

granules (using injection moulding)….but, they are not authorised for making granules from discarded plastic.” – (#84).

Evidence from secondary sources corroborates this. For example, an informal glass recycler creates negative externalities (Toxics Link, 2014). The glass from e-waste (i.e. CRT), though sold to glass recyclers, many of these glass recyclers do not adhere to safety standards. These recyclers recycle the glass into playing marbles, bangles, paper weight, bottles, etc. without removing toxic lead from glass. This negatively affects health of consumers who use these products. Thus, even if a Formal Processor does disassembly or metal recovery in a safe manner, negative externalities can be created by stakeholders (in the informal economy or does not adhere to safety standards) in the downstream.

Evaluation: Partial support was found for this proposition. Evidence from the field led to refinement of this proposition. We had discussed about negative externalities and occupational diseases w.r.t disassembly, metal recovery, and landfilling. But, we did not discuss regarding other processing operations like direct reuse, repair-cum-refurbishing, and cannibalization due to lack of evidence. Based on the evaluation explained above (vide P15.1 to P15.7), this proposition is revised as follows in Table 71.

Table 71: Evaluation of Proposition 15

Original proposition	*P15: Negative externalities are created by informal processors during the five processing operations on all types of products and landfilling; formal processors do not create negative externalities during the five processing operations on all types of products and landfilling.*
Revised proposition	*P15 (a): Formal processors minimize occupational diseases during disassembly, metal recovery.* *P15 (b): Informal processors create occupational diseases during disassembly, metal recovery.* *P15 (c): Formal processors minimize negative environmental externalities during disassembly, metal recovery.* *P15 (d): Informal processors create negative environmental externalities during disassembly, metal recovery.* *P15 (e): Formal processors minimize negative environmental externalities during landfilling.* *P15 (f): Informal processors create negative environmental externalities during landfilling.* *P15 (g): Other stakeholders, in the upstream and downstream, also create negative externalities.*

Proposition 16

P16: Retailers, dealers, manufacturers, informal processors, formal processors, scrap traders, secondary smelters are individual profit-maximizing stakeholders in the e-waste RSC.

Evidence from the field (NVivo node: *P16*)

Only one evidence was coded for this Node. This was when Informal Processor B purchased material from a Formal Processor who had further purchased from a MNC Bulk Consumer. This means that Informal Processors *interact* with Formal Processors. Evidence from the field suggests that Informal Processors interacts with Formal Processors in a way that is mutually beneficial. This interaction happens in both ways i.e. Formal Processors sell e-waste to Informal Processors; Formal Processors also purchase e-waste from Informal Processors or Scrap Traders.

Formal Processors sell e-waste to Informal Processor due to lack of capacity at their facility or inter-State transportation costs[38]. For example, if a Formal Processor based in Karnataka purchases e-waste from Kerala, he would carry it in a truck and before crossing the Kerala border, he would sell it to Informal Processors/Scrap Traders in Kerala. This is less expensive than paying the tax for inter-State transportation and further processing in his facility in Karnataka.

Earlier, while evaluating one of the previous propositions (Proposition 10) the confusion surrounding scrap trader and informal processor was highlighted. This concept of Informal Processor is fluid. For example, take the case of COOL, Informal Processor A, and Informal Processor B. COOL purchases customer returned products from retailers, repairs-cum-refurbishes and sells them in second-hand market. Informal Processor A purchases e-waste from Bulk Consumers, disassembles into commodities, and sells them to commodity recyclers. Informal Processor B also does the same operations as Informal Processor A. But, Informal Processors A and B regularly connects with stakeholders like COOL to sell products that can be repaired-cum-refurbished and sold in the second-hand market. All these three firms are

[38] This was revealed by the Founder of BB, when the researcher (doctoral student) was presenting findings of this dissertation to BB's team.

recognized by the State Government and have VAT registration. In fact, COOL had CCTV with 4 cameras: one camera inside the shop, two cameras at the entrance of shop in two angles, one camera on the nearby street (the street that leads to the shop). All these three firms can be called as Informal Processors, because they are not authorized by the SPCB.

Evaluation: This proposition was developed with the assumptions that Scrap Traders and Informal Processors are separate entities and Formal Processors do not interact with Informal Processors. These assumptions were not supported based on field evidence. In light of these evidence, this proposition is revised as follows in Table 72.

Table 72: Evaluation of Proposition 16

Original proposition	*P16: Retailers, dealers, manufacturers, informal processors, formal processors, scrap traders, secondary smelters are individual profit-maximizing stakeholders in the e-waste RSC.*
Revised proposition	*P16 (a): Definition of Scrap Traders and Informal Processors is fluid* *P16 (b): There is two way interaction between Formal Processors and Informal Processors.* *P16 (c): Retailers, Dealers, Manufacturers, Formal Processors, Commodity Recyclers are separate stakeholders.*

Proposition 17

P17: The e-waste RSC structure is decentralized and open-loop.

Evidence from the field (NVivo node: *P17*)

P17.1 Processing stage of RSC is decentralized

Though e-waste processing is happening throughout the country, it is more concentrated in areas around Delhi. This is evident from comments #4, #13, #16, #29. For example, Informal Processor B said the e-waste processing activities are happening everywhere, but is more concentrated in Moradabad (areas surrounding Delhi):

"Mostly in U.P...Moradabad...the entire city of Moradabad has dismantling, recycling, refurbish...everything...A to Z work [in e-waste] happens there...whatever information you want, you just visit there once...you will get shocked after visiting there...here, you will get some people in Goripalya, some people in Tannery Road, some people in Bismillah Nagar, some people in Nayandahalli...there [Moradabad] it is not like that...there, if you go to any street or any house you will find some work e-waste recycling...ladies, children...every house, every corner, every street, you will find people working on this [e-waste]...from small children to old aged people" – (#4).

Founder of RTH echoed a similar view:

"In India, every e-waste [especially, printed circuit boards] is going to Delhi...from Delhi, it is distributed. In Delhi, there are few places like Seelampur, Shastri Park, Mustafabad, Shahdara, couple of places there in Delhi...they are the hubs for electronic scraps...there are lot of Delhites and UPites, they are spread throughout India and they will collect this material from small companies, recyclers, and they are shipping to Delhi...from there, they are distributing to the local unorganised sector...that is the current scenario." – (#22).

P17.2 Processing stage of RSC is not decentralized

E-waste processing happens in major cities Bangalore, Chennai, Delhi, Mumbai, Pune, etc. because the quantity of e-waste is higher due to population, higher telecom density, presence of IT industry and manufacturing industry, etc. For example, a processor can purchase more IT hardware from Bangalore/Chennai/Pune/Delhi when compared to Guwahati. So, it does not make economic sense for processors (Formal or Informal) to locate their facilities in places having low e-waste generation capability. However, e-waste generated from places having low e-waste generation capability (Tier 2 or 3 cities/Rural areas) are transferred to the Processors in cities through the network of Door-to-Door Collectors and Scrap Traders. These are evident from comments #7, #9, #10, #13, #18, #26, #27. The stories are same across the cities whether Bangalore or Pune or Delhi and processing is happening in "pockets" across the country and the major pocket is Delhi[39] (#79).

Evidence from secondary sources corroborates this (#34, #35, #36, #37, #38, #39, #42, #43, #44, #45, #46, #47, #48, #49, #51, #54, #56, #57, #58, #61, #63, #64, #65, #68, #69, #70, #71, #72, #73, #74, #75, #76, #77).

P17.3 Final stage of RSC is not decentralized

This is evident from comments (#1, #8, #27). For example, informal processors sell glass (disassembled from e-waste) to firms in Meerut, to be made into bangles (#1). Recycling of copper, silver happens in pockets in Bombay and Jaipur respectively (#8). For example, Founder of Bravo said:

"Processing is not taking place except in hubs across the country....plastic processing to some extent will take place in Bangalore...but, smelting is a North Indian activity taking place in Rajasthan...so, those hubs you need to see...where are the copper smelters, where are the steel...the MS [mild steel], where does it go into...that's very much regional...even in the South, I don't think you have very much copper smelters" – (#27).

Data from secondary sources corroborates this (#40, #58). These indicate that commodity recyclers are majorly present in North India.

[39] This can be loosely thought of as a hub-and-spoke network.

P17.4 RSC structure is open-loop

This is evident from comments (#5, #6, #10, #11, #13, #14, #15, #18, #19, #23, #25, #30, #33). For example, the metal scrap from e-waste (particularly Mild Steel scrap) are used in foundries to make cast iron body parts which are further used for manufacturing automobile engines or other machinery in railways and construction sectors (#5). Proprietor of Poly said: *"this is a PP [pointing to plastic body of laptop]...means the body of a laptop or body of a television, and body of our refrigerator...many parts which is of plastic, and even that AC, airconditioner body...split AC...that is a PP."* – (#11). The casing/body of laptops, televisions, refrigerators, air conditioners, etc. are made of Polypropylene (PP). This PP is sold to plastic product manufacturers who convert them into granules and make plastic mugs, buckets of different colours (#11). From certain plastics, even oil can be extracted by pyrolysis (#23). This oil is then used in Diesel Generator sets (#23). For example, Co-founder of RWM noted:

"There are thousands of types of plastics. Some plastics yield you good amount of oil....some plastics are good for converting into pallets during recycling...so, depends" – (#23).

Based on the purity of gold and silver extracted from e-waste (by Formal and Informal Processors), they are sold to jewellery manufacturers (#13). Founder of EP explained the various aspects of where the disassembled commodities travel:

"Bailed computer cabinets goes for melting and becomes tor steel because the demand of tor steel in Bangalore is huge...used in construction, infrastructure...the aluminium from electronics immediately becomes automobile component in Coimbatore", "Plastics has excellent infrastructure within Bangalore...it is not send out of Bangalore...all type of plastics...ABS, HIPS, PP, PE, PC...most of them are recycled by palletizing and becomes another component...a monitor plastic becomes a voltage stabilizer, a switch box, and things like that...it is all happening here...it is not transported, though the demand is huge in other places.", "this glass goes to XYZ [a major TV manufacturer]...last month also, we have sent one shipment...full truck load of 16 tonnes, separate funnel glass and separate front glass...this again becomes a CRT picture tube...because the demand for the color picture tube is still there in India, though LCD has come" – (#30).

Data from secondary sources corroborates this (#50).

P17.5 RSC structure is closed-loop

There are some elements of closed-loop in the RSC. The PP from the plastic body of laptop can also be used to make the body of another laptop (#11). But, the finishing will not be smooth and shiny (#11). Founder of RTH said regarding how the loop closes:

"There is one company in Japan, they are also into refining...again they are producing circuit boards for the mobile phones...they are supplying to Samsung, Apple, Nokia, Motorola" – (#20).

These are evident from comments (#11, #14, #19, #20, #25). Data from secondary sources corroborates this (#50).

P17.6 Final destinations of e-waste in the RSC

This sub-section summarizes where e-waste goes after being processed by Processors (Informal or Formal). This aspect was not a part of this proposition. However, emergent theme from the field evidence was related to this proposition. Hence, this is included to enrich this proposition. The evidence for this sub-section are drawn from the Node: *Other final destinations*. After being processed by Processors, e-waste goes to the following stakeholders:

(1) <u>Commodity scrap traders purchase from processors</u>

Processors disassemble e-waste into commodities like plastic, iron, brass, aluminium, copper, etc. and sell to respective traders who are specialized in trading these metals. These commodity scrap traders can also be formal and informal. Informal processors sell to informal commodity traders, formal processors sell to formal smelters or formal commodity traders. However, there are formal processors who sell to informal commodity traders. Commodity traders or smelters also have flexibility to do transactions informally or formally. Formal transactions are done through bills and demand drafts (which includes taxation) while informal transactions are done through cash without bills. These are evident from comments #1, #7, #8, #12, #14, #15, #16,

#21, #25, #26, #28, #29, #31, #33, #64, #67, #70, #83. This is corroborated by evidence from secondary sources (#93, #94, #99, #102, #104).

(2) Commodity scrap traders sell to smelters/foundries[40]

From such traders, foundries (or smelters) will buy different types of scrap metal. For example, the foundry LDR buys scrap steel scrap from a formal scrap metal trader, melts it, adds other items (alloys, non-alloys) and makes cast iron body parts. These are then sold to automobile engine manufacturers (#8). Typically, scrap metal traders will accumulate scrap metal up to certain quantities and then sell to foundries. This is because smelters/foundries need higher quantities. For example, an aluminium smelter needs one truck of aluminum (i.e. 10 tonnes of aluminium scrap). Commodity scrap traders purchase aluminium from e-waste processors and other sources and aggregated up to this minimum quantity of 10 tonnes and sells to aluminium smelters. The case of boards are also similar. Board traders collects from processors, aggregated to a certain quantity, and sells to Precious Metal Refiners abroad. These are evident from #1, #3, #8, #14, #15, #16, #18, #21, #25, #26, #34, #37, #38, #39, #41, #52, #53, #54, #57, #66, #69, #75. This is corroborated by evidence from secondary sources (#91, #92, #98, #102, #104, #116, #120, #121).

For example, Founder and MD of RML said: *"See, we are raw material processers, we process and give raw material...they convert them into usables, we give them meltables [metals that be melted]. They melt it, alloy it to a certain requirement, pass it on to component guys. The component guys make into components and give it to original equipment manufacturers. That is the end of the equipment [i.e. the final product]. From there, the usage starts and then their waste...their discard starts. The last stage of the life is end-of-the-life. That's how this cycle goes on."* – (#38).

So, smelters are recyclers who melt scrap metal and convert it into some solid forms like ingots, bars, rods, etc. Or, these smelters, at an abstract level, can even by recyclers who make granules by melting plastic. These granules are then sold to plastic product manufacturers. These smelters can also be precious metal refiners who are located abroad. Founder and MD of MMT said that his firm imports metal scrap, sort and segregate them and sell to smelters (#19). The

[40] Smelters/foundries are called as 'commodity recyclers' in this dissertation.

smelters make rods, bars, wires for various sizes and sell to manufacturers who make metal tips for ball pen; spectacle hinges; bicycle tube walls, tube light pins, etc. (#19). These manufacturers further sell to firms that makes or assembles the finals products (#19). For example, Sales Manager (India and Middle-East) at IMU said:

"We [precious metal refiners] collect e-scrap from various countries including countries in Asia. We do not collect the product per se. We collect motherboards, circuit boards, chip boards of e-scrap. There are dismantlers like EP in India who collect e-scrap and dismantle them into plastic, ferrous, non-ferrous, and boards…they also shred the boards. We collect shredded boards from such dismantlers. If dismantlers cannot shred them, we shred the boards after collecting it. We collect all types of boards i.e. boards from all products", "After recovering the precious metals, they are sold in the market at that day's market price. These metals are not sold at scrap prices because we have the technology to extract metals with extreme purity...even the copper we extract gets sold at LME prices…LME grade copper…this is unlike a recycler in India, who extracts copper and sells it at scrap price, at a discount. By LME grade, I mean our plant is audited and approved by LME." – (#34).

Formal processors can sell these commodities directly to smelters or they can sell it to trader who will further sell to smelters. This decision depends on the minimum quantity needed by the smelter, cash cycle of the processor, etc. For example, Business Development Manager of Epsilon said:

"If you ask the recycler [e-waste processor] to give to the smelter...he [e-waste processor] would have invested money in the raw material...he will have to block it...because, the smelter will ask for that quantity...smelter will ask for 20 tonne...if I keep accumulating till it reaches 20 tonne, it will take 6 months...till then, my money is blocked...so, due to this, we give it away [to scrap traders]...so that, some money gets released." – (#30).

If processor sells to a smelter, he will get higher money than giving to a trader (#15). Business Development Manager of Epsilon explained regarding this:

"If you go to Mothi Nagar, you've so many people who are buying old iron...what they do is...they are just collectors...they collect and accumulate and send it to a smelter at X price...so, they'll have some margin in that. If we sell, say, 500 kilos or 100 kgs or 1 tonne...it'll not work

out based on transportation and all...that fellow [smelter] will ask for a 20 tonne minimum lorry...so, that's why we sell it to a somebody with some lesser price [i.e. if I sell 20 tonne directly to smelter, I will get Rs. X per kg...but, if I sell some 5 kg or 1 tonne to the trader, I get less than Rs. X per kg]" – (#28).

(3) Dealers in the second-hand market for products and parts, purchase from processors

This is evident from comments #17, #24, #43, #55. For example, COOL is a scrap dealer who repairs and sells products to other dealers in second-hand market. COOL also has its own second-hand goods shop. Proprietor of Poly said:

"On Sunday, next to Jolly market...this Mamulpet...there you will find...a kind of Chor Bazaar it is...there you will find each and everything....whatever you want...even if you are having a lambrator scooter...and you are not getting a part anywhere...on Sunday you reach this Jolly market and this area, may be you will get that part also." – (#24).

(4) Manufacturers purchase commodities (like metals, plastic) from processors

Precious metals extracted by processors are not sold to scrap traders. They are directly sold to manufacturers. What is sold in scrap markets are ferrous metals, non-ferrous metals, and plastic (#32). Business Development Manager of Epsilon said:

"Jolly Mohalla...gold and silver people are not there. We give it to this CMR [a dominant jewellery brand]...like this...big big people are there" – (#32).

Another example is that of an informal firm where copper, aluminium, PVC are taken out from wires and sold to a major automobile brand who uses these for making wiring harness (#72).

Evidence from secondary sources corroborates this (#99, #119, #124).

Evaluation: This proposition is partially supported. Evidence from the field revealed that he concepts decentralization and open-loop should not be taken as dichotomous, rather it should be seen a continuum. The idea behind saying open-loop is this: RSC structure more tends towards an open-loop and less towards a closed-loop. Also, field evidence led to certain

nuances like the separation of processing and final stages of RSC to understand decentralization and open-loop/closed-loop. In light of these evidence, this proposition is revised as follows in Table 73.

Table 73: Evaluation of Proposition 17

Original proposition	*P17: The e-waste RSC structure is decentralized and open-loop.*
Revised proposition	*P17 (a): The e-waste RSC structure is not strictly decentralized. The processing stage and final stages of e-waste RSC has different levels of decentralization. Final stage is more centralized than the processing stage.* *P17 (b): The concepts of decentralization and open-loop needs to be considered as a continuum.* *P17 (c): The e-waste RSC structure tends more towards open-loop.* *P17 (d) After being processed (by Processors), e-waste reaches commodity scrap traders, commodity recyclers, second-hand market dealers, and manufacturers.*

Proposition 18

P18: EMHR has not caused significant changes in the e-waste RSC. There may be some links in the RSC that were created or destroyed after May 2012.

Evidence from the field (NVivo node: *P18*)

P18.1 EMHR modified the RSC structure: new links created

The new links are as follows: some bulk consumers (who were giving e-waste to informal processors) have started giving e-waste to formal processors only; some retail consumers are giving e-waste only to authorized collectors or formal processors or manufacturers; some manufacturers have set-up collection systems to collect e-waste from retail consumers and these manufacturers give them to formal processors; some manufacturers have also tied-up with formal processors to collect and process e-waste on their behalf; formal processor gives non-recyclable and hazardous materials to TSDFs. For example, Sr. Director of Manufacturers' Association said that all IT hardware manufacturers have set-up take-back systems and have tie-up with one formal processor to whom they give all the collected e-waste (#4, #6):

"All IT hardware manufacturers have a take-back system in place. For example, LED has a take-back system. Consumers can dispose LED at their collection centres and get paid Rs. 500. But, many consumers do not do it because they get Rs. 1000 if they dispose with informal recyclers." – (#6).

These are evident from comments #2, #3, #4, #5, #6, #7, #12, #13, #14, #16, #20, #21, #22, #28, #32, #33, #47, #48, #50, #51, #53, #56, #59, #60, #63, #64, #207, #208.

Evidence from secondary sources corroborates that the structure of RSC was modified i.e. new links were created (comments #66, #68, #70, #71, #72, #73, #76, #78, #88, #89, #94, #98, #101, #102, #110, #114, #117, #118, #119, #128, #135, #137, #140, #143, #144, #145, #147, #148, #150, #154, #156, #163, #166, #170, #174, #175, #176, #178, #183).

P18.2 Many stakeholders game the system; occupational diseases and negative environmental externalities continue to persist

Many stakeholders in the RSC game the system i.e. they comply with EMHR on paper, but in reality they do not comply. For example, formal processors after picking up e-waste from Bulk Consumers' premises, dump non-recyclable materials on the way to their facility; formal processors sell e-waste to informal processors; formal processors sell disassembled commodities to informal commodity traders; Informal Processors use the license of Informal-turned-formal processors to purchase e-waste and process informally; bulk consumers borrow a copy of license from formal processors and transfer it to their personal contact, to whom they would sell e-waste; etc. For example, Informal Processor B said:

"What does even e-waste guys [i.e. Formal Processors] do? Those who are in the formal...after making e-waste companies...what do they do? They run the company...but, do not work...they will give everything to us...99% e-waste guys [formal e-waste processors] are selling all their material to informal guys only...tell me one person [formal e-waste processor] who collects and does work himself. There is no one like that...everyone is giving to informal guys only" – (#7).

Founder of an NGO said: *"So, some of the recyclers are acting as agents...they are using the license to collect materials from the fair market and throwing it back in the same market...the objective of the Rules to shift the market into the green channel of recycling, did not have any change. So, despite having one of the finest legislation you can get in the world, we still have business as usual."* – (#56).

These are evident from comments #2, #7, #21, #22, #23, #28, #29, #47, #48, #53, #56, #59, #60, #63, #64, #206. Evidence from secondary sources corroborates this concept of gaming the system (#86, #88, #89).

Why does formal processor sell e-waste to informal processor or informal commodity trader[41]?

It is worthwhile to understand this. Formal Processors, after purchasing small quantities of e-waste, need to make revenues from it (after processing) in the shortest possible time. Rather than spending a week on processing a small quantity of e-waste, they would prefer to spend a week on higher quantity of e-waste that has higher recoverable value. So, these small quantities of waste are sold to Informal Processors (which helps to make revenues quickly) so that efforts

[41] An alternate explanation for this is provided in Proposition 16.

can be directed to purchase and process high quantity e-waste. For example, Informal Processor B (who regularly purchases e-waste from formal processors) said:

"They have invested lakhs of rupees to make a e-waste...after making the e-waste certificate, they are not getting, first of all, material properly...after getting the material also, some small quantity...they can't keep on screwing and screwing everything and scrapping everything if they do, they will take some 4 to 5 days...within the 4 to 5 days, what they have to do? For one material if they take 1 week and 15 days...within 1 year, they will have to shut down all the godown...why? Because you are getting a small quantity of material...so, what will they do by getting this...they will not work on it...they will sell it...'anybody please come and buy this'... 'we need to buy the second material [material from other sources] and bring it' " – (#7).

In a similar vein, Founder of RTH said:

"We don't want to adopt corrupt practices...but, for survival we need to adopt them...we fall in line with them. I wish, we do not go in that path...but, if I don't go in that path, I will not survive...I need to shut down my business." – (#22).

Formal Processors also sell the disassembled commodities to informal commodity traders. The informal traders can pay a higher amount and can purchase immediately vis-à-vis formal traders. So, the fundamental business question for the processors is this: how can the purchased e-waste be quickly processed to realize revenues in the shortest possible time.

A more elaborate discussion of stakeholders gaming the system can be found in Theme 6 in Chapter 5.

P18.3 Though EMHR modified the RSC structure, old links persist

Many stakeholders do not comply with EMHR. Retail consumers do not return used products to manufacturers and prefers to sell to door-to-door collectors; bulk consumers continue to give e-waste to scrap traders/informal processors; informal processors continue their informal ways of processing; etc. For example, Informal Processor B said about Government's plan to close down informal processors:

"If it is closed here, it will start work in a second place...if it is closed in the second place, it will start work in a third place...how many places will you close down? Where all you will you close down?" – (#8).

Founder of EP said: *"When I started in 2004, 95% of e-waste was going to informal sector...even now, it is the same or even increasing...may be, it is 96% now...this is because of the pricing problem. We are feeling the pressure."* – (#45).

Co-founder of RWM said that stakeholders do not comply due to lack of strict enforcement and penalties for non-compliance:

"The Rule says that bulk generators must give their e-waste to authorized recyclers. What will you do if I don't give? That you have not specified. So, it's like..."Ok, I will get a remark in my audit". So, what if I don't comply? There is no clear answer to that. There is only a "we will put a remark in your audit"...so what? Who cares? As a manufacturing company or any company for that matter, they are concerned about their shareholders...maximizing the shareholders' wealth. Now, whether by getting a memo that I am not complying with E-waste Rules...if it doesn't affect my shareholders' wealth, how am I bothered? I am not really bothered. That's where the problem is." – (#25).

This is evident from comments #8, #9, #13, #14, #18, #19, #20, #24, #25, #26, #27, #28, #30, #31, #32, #35, #38, #39, #40, #41, #42, #43, #45, #46, #49, #50, #51, #54, #55, #57, #58, #61, #62, #207, #208. Evidence from secondary sources corroborates this (#65, #67, #68, #69, #70, #71, #73, #77, #78, #89, #96, #97, #101, #102, #110, #113, #114, #117, #118, #121, #122, #124, #137, #140, #142, #147, #146, #151, #152, #153, #155, #156, #157, #158, #159, #161, #162, #163, #164, #165, #166, #167, #168, #169, #172, #173, #174, #175, #176, #177, #178, #179, #181, #183, #184, #185, #186, #188, #190, #191, #192, #193, #195, #196, #197, #198, #199, #200, #203).

Evaluation: Though some stakeholders comply with EMHR, thus modifying the structure of RSC (vide P18.1), some stakeholders game the system (vide P18.2) or do not comply with EMHR (vide P18.3). Thus, negative environmental externalities and occupational diseases continue to persist (vide Proposition 15 that formal processors reduce negative environmental externalities and occupational diseases more than informal processors would). It is interesting

to observe that EMHR has created a system in the e-waste RSC where some stakeholders comply with the legislation, some stakeholders do not comply due to poor enforcement and opportunities for high payoffs by gaming the system. These non-complying stakeholders enter into a state of suspended animation i.e. they keep doing their business as usual, as if EMHR did not exist. Due to this, e-waste RSC as-a-whole does not comply with EMHR and negative externalities continue to persist. This situation, in the e-waste RSC, is called a *livelock*[42]. This concept is borrowed from computer science and automated manufacturing systems literature (Chandrasekaran et al., 2015; Sreenivas, 2016). In light of these evidence, this proposition is revised as follows in Table 74.

Table 74: Evaluation of Proposition 18

Original proposition	*P18: EMHR has not caused significant changes in the e-waste RSC. There may be some links in the RSC that were created or destroyed after May 2012.*
Revised proposition	*P18 (a): EMHR modified the structure of RSC: new links were created.* *P18 (b): Though EMHR modified the RSC structure, old links persist due to stakeholders' non-compliance and gaming the system.* *P18 (c): EMHR created a livelock in the e-waste RSC.*

[42] It is to be noted that a *deadlock* is different from a livelock. If it was not possible for transactions or trades to be executed in the RSC due to EMHR, then we could say that RSC is under a deadlock.

Emergent Themes

Apart from using evidence to evaluate these propositions, more evidence emerged from the field (inductive) that enriched the conceptual framework. These evidence are conceptualized under appropriate themes and summarized below.

Theme 1: Tacit Knowledge in the informal economy

This theme is regarding Tacit Knowledge in e-waste processing operations and pricing, prevalent in the informal economy. Tacit knowledge cannot be codified or made explicit in written or verbal form (Polyani, 1966; Lam, 2000). For example, human being's ability to recognize faces is tacit knowledge:

"We know a person's face, and can recognize it among a thousand, indeed a million. Yet we usually cannot tell how we recognize a face we know. So most of this cannot be put into words." – Polyani (1966).

Such tacit knowledge exists among stakeholders (Informal Processors/Scrap Traders, Door-to-Door Collectors, etc.) in the informal economy. This knowledge is regarding the market i.e. At what price to purchase e-waste from bulk consumers? What price would the product or parts or disassembled commoditied get sold (given the fluctuation in prices)? Who are the buyers? What is the nature and quantity of commodities inside the product? Which processing operation would fetch the maximum value?

Evidence from the field (NVivo node: *Tacit knowledge in informal economy*)

Evidence for the presence of this tacit knowledge is based on comments #1, #2, #5, #6, #8, #9, #10, #11, #12, #13, #14, #15, #17, #18, #22, #23, #24, #26, #28, #29, #31. For example, Informal Processor A spoke about how he quotes price to the consumers while purchasing e-waste from them:

"We have experience", "We know that if CRT monitor is dismantled, we will get 2 kg plastic, 400 gm copper", "That calculation is prepared in us...we have gained experience by doing this over years...now, if a guy comes with CPU...inside that, the motherboard will be 550 gm, power supply will be 2 kg, some power supply will be 1.5 kg, some other power supply will be 1 kg,

there will be 4 kg iron, some will have 7 kg iron...some will have motherboards of 450 gm, some will have 500 gm, some will have 600 gm...like this, we make all calculations and quote an amount of Rs. 30 per kg, Rs. 20 per kg, Rs.10 per kg" – (#1).

He also said the boards inside the products fetch different value in the market based on the content of precious metals like gold. He segregates these boards based on the metal content and type. He can tell how much money it would fetch in the market, by visually inspecting the item:

"We have experience in that...we can tell that just by seeing" – (#2).

This ability to do pricing based on deep experience, by just "seeing" the material is also corroborated by other stakeholders including Informal Processors, Consultants from STIMULUS, and Formal Processors. For example, Consultant X described the knowledge level of informal processors:

"You ask an Intel guy what kind of things are there in the computer…they won't know every chip and what is the number on it. You go to an informal recycler and ask him, he will tell you each and every component in a computer and what is the number on that, what is it, how is it used…and these are all, mind you, uneducated people. That's the kind of knowledge they have." – (#5).

As part of this study, visit to a small-scale plastic granule manufacturer was made. The employees tested quality and grade of plastic granules by biting using teeth (without using any equipment). We were given two samples of plastic granules and both samples were neatly covered in a plastic cover. Visually, we could not distinguish between the two samples and both seemed alike. Actually, one sample was LD (low density plastic) and another sample was PP (polypropylene). This can be known manually, *only* by biting it. PP is harder than LD. There are other attributes, which can be known by biting, apart from hardness. But, these are difficult to know for outsiders. The employees were able to distinguish between sacks (1 sack = 1 tonne) of LD and PP, by taking 2-3 granules and biting them. It is through these 'tests' that business transactions are done. Such tacit skills of the informal sector were also mentioned by the Founder of EP during a stakeholders' seminar.

Evidence from secondary sources hint at this concept of tacit knowledge, in a different but similar context of end-of-life vehicles recycling (#32). Ian Hetherington, Director-General of the BMRA (British Metals Recycling Association) said regarding the *skills needed* for end-of-life vehicles recycling:

"The industry requires very capable people doing the job of collecting and sorting. The big secret of the industry is its skills level. It takes skill to differentiate between three grades of brass when someone brings in a car-load of brass fittings. Equally, sorting through a 30- tonne load of stainless steel is often done by a crane driver sitting 40ft above it. It's a very high level of skill." – (#32).

This fundamental concept of high skill levels in India's informal economy for e-waste collection and segregation (i.e. disassembly), was mentioned by Consultant X, Founder of EP, Consultant Y, and many other stakeholders during the interviews and stakeholders' meetings.

<u>Sources of this tacit knowledge</u>

Potential sources of this tacit knowledge in the informal economy are deep experience in the scrap commodity (e.g., scrap metals) industry (before e-waste started entering the waste stream) and knowledge gained through generations. These are evident from comments #3, #4, #11, #19, #20, #21, #31. For example, Business Development Manager of Epsilon claimed that informal processors recover higher yield (more than 90%) of precious metals when compared to precious metal refiners in Germany who realizes a yield of 60-70%. He had observed this during his recent visit to precious metal refiners in Germany. Consultant Y said about the neighbourhood in Bangalore where informal processors co-exist:

"Several ancestors of the present generation were engaged in scrap business i.e. buying scrap from factories, segregating and dismantling them here…then, when computers and electronic equipment came these factories started giving this electronic scrap also to them…these people who were engaged in scrap business learnt to operate on electronic scrap based on their previous experience with other scrap like iron, metals…and experimentation…they learnt to extract precious metals from this electronic scrap" – (#19).

Theme 2: Technological Change and other factors

Evidence from the field (NVivo node: *Technological Change*)

<u>Amount of metal content in products</u>

The amount of metal (including precious metals, ferrous, non-ferrous) content in products has reduced over a period of time. This is evident from comments #1, #4, #9, #10, #15, #16, #23, #24, #27, #37, #44, #46, #59, #60. For example, Informal Processor A said that PCBs of products coming from China is fetching him only Rs. 70-80 per kg due to lower quantity of metals. Whereas, PCBs of products not coming from China fetches him around Rs. 220 per kg due to higher quantity of metals. Head of Sustainability at AIK, also concurred with this:

"There is difference in the precious metals that are available in different brands of phones…for example, Nokia, Blackberry, Samsung, etc. would give better returns in terms of materials….you can find high value materials in their phones…Chinese phones would have very low value…because, they do not use precious metals, good materials." – (#33).

Managing Director of Component Manufacturers' Association quoted the example of metal cages in the context of telecom industry. Earlier, the cages used to be made of metals and was of great value to the scrap metal recycler. But, now these metals are substituted with plastic which has lower value than metals. The point to note is that ultimate scrap value is in the metals. Managing Director of Component Manufacturers' Association said:

"The metal...whichever way it comes in...it is a money for the scrap person... so, metal from building debris or PCB...it has got the money value...so, this is only a unquoted fact...giving an intimation that all the scrap value is in metal only...not in plastics, not in any polymers" – (#4).

However, there is also contradictory evidence that metal content is not reducing for all kinds of products and in some cases metal content has actually increased or more valuable metal is being used. This is evident from comments #2, #36, #37, #38, #41, #42. For example, Senior GM of Sales of a large PCB manufacturing firm said:

"The amount of precious metals in PCBs have actually increased…especially due to RoHS…earlier there used to be lead finishing…but, now due to RoHS you cannot have lead finishing…now it is gold finishing…so, the amount of gold has gone up by 60% because of RoHS." – (#38).

Data from secondary sources corroborates this evidence that metal content is not reducing (#69). Also, there is always a bare minimum quantity of precious metals needed for electronic products, their quantity is not as high as earlier (#35, #39). For example, Proprietor of Delta said that there needs to be minimum amount of gold, silver, platinum, etc. in any electronic product due to their higher melting points (ability to withstand the heat generated). So, even though the amount of gold coating has reduced, there is a bare minimum amount that needs to be present.

New materials are being substituted that have low recyclability

If recyclability is low, then its demand is low in the market and does not get picked up by scrap traders or smelters. This is evident from comments #8, #16, #46. For example, as discussed in the chapter on formalization, laptop casing has moved from plastic (recyclable) to bakelite (non-recyclable and can only be incinerated).

Miniaturization has reduced the volume of products

Miniaturization, in a loose sense, implies the trend of manufacturing smaller and smaller devices. This also leads to reduced weight of product owing to smaller sizes (i.e. smaller volumes). This is evident from comments #3, #4, #7, #16, #17, #21, #22, #23, #29, #34, #47. For example, size of monitors, CPUs, hard disks have reduced and capacity has increased. Founder of RTH said regarding the reduction in the size of products:

"The sizes have become compact everyday...when you were buying P1, P2, P3 [computers run by Pentium processors] their sizes were big...earlier, the laptop used to weigh 5 kg; now, the laptops weight 1-1.5 kg...earlier, the PC i.e. desktop used to weigh 12 kg; now, it is 6 kg...earlier, CRT monitors used to weigh 15-20 kg; CRT monitors have got over and now there is LCD monitor that weighs 1-1.5 kg...so, the size has reduced...suppose, 5 years back you are

collecting around 500 MT every month, if you were working with IT...but, today you will get only 250 tonne...in volumes, you will get 250 tonne" – (#23).

Interestingly, Product Take-back Manager of LED said that this reduction in size and weight of products had implications for take-back from a Manufacturers' perspective:

"We had set a target in 2008 for collecting 1 billion pounds by 2013…we have exceeded the target…we collected 170 million pounds…now, we have set a target of collecting 2 billion pounds by 2020…there is difficulty in achieving this because the weights of our products have considerably gone down…though the number of products sold have increased, their weights have decreased" – (#34).

Other changes in product design/evolution of products/technology

Certain products do not exist anymore or is reducing. Sometimes, the product itself evolves. This is evident from comments #2, #4, #7, #16, #17, #29, #30, #32, #43, #45, #48. For example, calculators, cameras, etc. (which were stand-alone products) are now built in mobile phones i.e. the production of calculators, cameras, etc. has reduced drastically. There is also a trend to make thin light-weight products i.e. products are becoming lighter and lighter as technology improves. Some responses also pointed towards made-to-break or planned obsolescence i.e. when a product's (say, smartphone or computer) hardware becomes incompatible with the new software version (operating system), consumers have no choice other than dumping this product and purchasing new product. Evidence from secondary sources corroborates this (#61, #62, #64, #73, #75).

Impact of all these changes on e-waste Processors

On a per product basis, these changes have negatively affected the revenues of Processors (Informal or Formal). These are evident from comments #9, #7, #10, #11, #16, #22. For example, Informal Processor B said that this was negatively affecting his business:

"Earlier, even for doing scrap [i.e. disassembly into commodities] one used to get money...now, there is not much money in doing scrap...earlier, hard disks used to come in bigger size...so, metal content was higher...now, size has become small...so, metal content had

reduced...price is the same...but, after doing scrap you don't get that much profit as you were getting before. Earlier, the margin was like...you will get 50 to 70% as profit after dismantling...but, now it has reduced to 10%, 5% profit" – (#7).

However, since the quantity of electrical and electronic products are increasing, some Processors have not yet realized the negative effects on their revenues. This is evident from comments #2, #12, #29, #21, #27. For example, Co-founder of RWM said:

"The amount of gold and silver that used to be there is reducing now. But, at the same time...overall volume itself is increasing at a very rapid state...so, that is compensated." – (#27).

But, the increasing number of e-waste Processors would again compensate for this higher quantities of e-waste and Processors would begin to realize the negative effects on their revenues. Interestingly, many Processors revealed that the purchase price of e-waste has increased due to competition in the industry. For example, Business Development Manager of Epsilon said:

"When I came into this business, people are making doubling money...doubling the money...buy for 100 rupees, they used to make 100 rupees profit...if we invest 1 rupee, we could make 2 rupees...we could even make 3 rupees. When we came into this business, people are making this kind of margins here...but, then lot of recyclers came in...they started competing...they increased the price. The board which is 1,000 rupees a kilo now, it used to be 300 rupees, 350 rupees those days. Now, many recyclers have come...all of them have come to know that gold can be taken out...they started competing." – (#15).

Theme 3: Influence of international commodity prices

All financial transactions (i.e. pricing) that happen throughout the e-waste RSC is dependent on international metal/commodity prices. Thus, stakeholders in the e-waste RSC are price-takers and not price-setters. It was found in Proposition 5 that the scrap value of e-waste (i.e. when e-waste can only be disassembled into commodities) is proportional to commodity prices. When e-waste gets disassembled into plastic, ferrous and non-ferrous metals, precious metals, the prices of these are dependent on international commodity markets. The commodity prices are decided in the international commodity markets. For example, price of scrap aluminium parts disassembled from e-waste in Bangalore is dependent on the spot aluminium price traded in international commodity markets. This theme can also be connected or extended as part of Proposition 5.

Evidence from the field (NVivo node: *Influence of international metal prices*)

Price of scrap metals (ferrous, non-ferrous, precious metals) disassembled or recovered from e-waste is dependent on International metal prices (driven by London Metal Exchange)

Though there are other trading exchanges, LME is benchmark that determines the prices of metals. The price of respective metals at LME, decides the price of respective metal disassembled or recovered from e-waste. Price of plastic is dependent on oil price in the international market. This relationship exists in informal and formal economy across all stakeholders i.e. it does not matter if one is a Big Formal Processor or Informal Processors/Scrap Trader or Informal-turned-formal Processor or Commodity Trader (Formal or Informal) or Commodity Recycler (Formal or Informal). This dependency on international metal prices is reflected even when Processors purchase e-waste from the Sources (i.e. Retail Consumers, Bulk Consumers, PCMs). For example, Consultant X said regarding how Informal Processors closely follow the international metal markets:

"That's again another interesting thing…all these really uneducated people…but, they keep a track on the international metal price and they know that next month this price might go up…so we won't sell it now, keep it, hoard it…in their place. Then, wait till the prices go up and then they sell." – (#22) [Other factors influencing economic value].

Informal Processor B said regarding commodity price fluctuations in the e-waste processing business:

"Price fluctuations keep happening...the rate that is there today morning will not be there today evening...majorly based on gold price, our business also moves up-down up-down", "The price in gold market...you can see that daily...sometimes it is 2850 per gram, sometimes 2855...sometimes it will be 2875...sometimes 2300...based on the market value of the gold, we will decide the prices...based on the gold market only, we decide the prices...it will be high sometimes, it will be low some other times. When the gold price changed to 8000 [sometime recently], the price of everything else increased...PCB boards, IC boards, this board, that board...for everything the price was high...material that used to sell at Rs. 250-300 per kg, began to sell at Rs. 400...from boards, gold is extracted...gold, silver, platinum, iron, copper...these items can be extracted from PCBs" – (#11) [Other factors influencing economic value].

A Metal Trading Analyst said regarding the business of scrap commodity trader and how it is connected to the business of e-waste Processors:

"Suppose, LME is going to fall...so, what the trader will do? Trader will try to sell max [maximum] material at today's price...and he will buy material after, say, 5 to 10 days...not right now...so, the current demand of that metal will go down in trader community...so, if you are going to sell the product [scrap metal] to the trader, you are going to get lesser money." – (#10).

Sales Manager (India and Middle-East) at IMU said regarding his business of collecting printed circuit boards from India and shipping it abroad (in containers) for precious metal recovery:

"One container's capacity is 20 tonnes…1 container of mobile phone boards [i.e. 20 tonnes of mobile phone boards] will fetch you 60,000 – 65,000 euros…1 container of laptop boards will fetch you around 40,000 euros…you will get this much amount of money when you sell those boards. Of course, today these prices have come down…because, the market price of metals have come down…gold prices have declined. These prices are dependent on movements in LME." – (#12).

These are evident from comments #1, #4, #6, #7, #8, #9, #10, #11, #12, #13, #14, #15, #16, #17, #20, #21, #22, #24; and comments #6, #11, #13, #20, #21, #22, #27, #30, #44, #46, #47, #51, #56, #65, #67, #75, #77, #123 from the Node: *Other factors influencing economic value*. Evidence from secondary sources corroborates this (#25, #26, #32).

Pricing of scrap metals disassembled or recovered from e-waste

Scrap metals are typically priced as a percentage of virgin metal price being traded at LME. Suppose, the virgin metal is priced at Rs. X (with 0% impurity), scrap metal price with a 1% impurity would be priced at a discount of some percentage of X. If scrap metal's purity is 99%, then its price is 1% (or some other positive number) less than the virgin metal price. This percentage discount is dependent on the exact nature of impurity and what would the purity be, after melting it. There are also situations, not frequently, where scrap metal prices are higher than virgin metal prices. This happens due to various reasons: when metal prices at LME are very low, or when there is higher import duty for scrap metal. When such situations occur, smelters prefer to use virgin metal rather than scrap metal. These are evident from #10, #13, #15, #9, #23, (#418) [Role of scrap metal supply chain].

It is to be noted that daily benchmark spot prices of metals are characterized by volatility due to supply and demand factors, seasonal variations, international political negotiations, industry cycles, etc. Understanding the nature and causes for movements in metals prices, are outside the scope of this dissertation.

Theme 4: Nature of the e-waste processing

There are some unique characteristics of this industry, from the perspective of Processors (Informal or Formal). These are described below.

Evidence from the field (NVivo node: *Nature of e-waste processing*)

<u>Timing and Quantity of e-waste supply are not predictable</u>

Processors face the challenge to ensure steady supply of adequate quantity of e-waste to keep their facilities in a running condition. Processors cannot plan how much e-waste they can purchase in a quarter or year, because e-waste availability (timing and quantity) from Sources are not predictable. Consequently, their revenues keep varying. All evidence from primary and secondary sources reveal that the Formal Processors operate at 25-30% (or less) of the installed capacity due to lack of e-waste availability. Formal Processors also said this during informal conversations at stakeholders' meetings. For example, Manager of GKN said regarding their plans for diversification:

"We are planning to start plastic granule manufacturing also…to diversify from e-waste…we are not getting enough e-waste. There is a lot of demand for these plastic granules…and you will get plenty of plastic scrap to melt it and make granules out of it" – (#102).

Informal Processor A said regarding the unpredictable nature of e-waste supply:

"What happens in business is...we travel to many places...here and there always...from some places, we get 2 CPUs...sometimes, we get 1000 CPUs...sometimes, we get 100...sometimes, we get 10...we put in all our effort to run our business...whatever we get, we do management on that and keep going...during some years, we are able to earn Rs. 2 lakh...during some other years, it becomes Rs. 3 lakh...some years, there are no earnings at all...monthly, sometimes we earn Rs. 50,000...sometimes, we earn Rs. 30,000...sometimes, we also earn Rs. 1 lakh...we cannot say [exactly how much we can earn every month or every year]...ours is not standard level [i.e. there is no constant/steady income]...we keep moving up and down...sometimes, we earn...sometimes, we don't earn...we do not have a straight level" – (#1).

The major problem with the unpredictable timing and quantity of e-waste supply is that resource planning is not possible. For example, Business Development Manager of Epsilon said:

"If we get everything at a X price, round the year we'll have work...we'll have some work to do...very often, what happens is, we will not have any work every 15 days...because, there is no material...we have to pay salaries on a monthly basis...because, labour will run away [if we don't pay them salary]...sometimes, there is work...sometimes, there is no work" – (#32).

These are evident from comments #1, #6, #34, #76, #88, #112, #132, #102, #109. Evidence from secondary sources corroborates this (#135, #136, #154, #155, #158, #168, #199, #200, #201, #209, #213, #219, #220, #222, #223, #228).

<u>E-waste consists of heterogeneous products and this heterogeneity is not constant</u>

Typically, an e-waste processor receives the following types of e-waste: printers, fax machines and copiers; motherboards and printed circuit boards; CDs, floppy disks, tapes and cartridges; telephones, cell phones and telecom equipment; TVs and other audio and video devices; dry cells and lithium batteries; microwave ovens and washing machines; medical electronics, scanners and MRI machines; industrial, military and aerospace electronic equipment; and IT hardware including enterprise servers, desktops, laptops, wires, tablets, etc. Each of these products are different and they do not come in constant rates (varying quantities) across the year. This heterogeneity and quantity variation in e-waste supply is a challenge to Processors. For example, Informal Processor A said:

"The material that has come this time will not come next time...the material that will come next time, will not come the next time...like this, products keep on changing, material also keeps on changing. There was some difference in the last PCBs...last time's PCB boards were different...the PCB boards coming now are different from the last time....last time's PCBs used to fetch us Rs. 220...the PCBs coming now, is fetching only Rs. 80, Rs. 70...there is no good metal in it" – (#2).

Due to this heterogeneity in e-waste supply, processing costs also differ. Recovery gold from gold coated components or recovering silver from silver coated components incurs different

costs because the chemicals used are different. But, processing a washing machine or refrigerator incurs only the labour costs for disassembly because hardly any metals can be recovered from their boards. The cost of metal recovery would be 20-25% of the purchase price of e-waste, and cost of disassembly would be 12-15% of the purchase price of e-waste. Big products like servers incur lower disassembly costs when compared to small products like mobile phones. This was articulated by the Business Development Manager of Epsilon:

"For example, if you have a phone...phone needs lot of labour...it has many things that needs to taken out and separated...the boards inside the phone has many small small things...it takes time to separate those things. The bigger the electrical item is, the more easier it is to dismantle...smaller ones are difficult...for example, if I open this [audio recorder], you will need to separate the board, speaker...they have metal...those metal parts are small small things...it is labour intensive, actually. If we have a server, what is there in that? There are only cards in this big almirah type thing...take out the cards, take out the plastic caps...and send the boards for recovery...hammer the almirah, and send it to scrap iron traders. So, material to material it varies." – (#30).

Apart from costs, the processing operation (what processing operation to be done on what product and how to do it) will also differ based on the nature of product.

These are evident from comments #2, #28, #30, #56, #69, #113, #114, #119, #75, #140.

<u>Nothing is a "waste", if there is a market for it</u>

If direct reuse, repair-cum-refurbish, cannibalization are not possible, e-waste is disassembled into commodities and metal recovery is done from metal coated components. No parts/components inside e-waste is wasted or disposed if it has a buyer (i.e. market). For example, Consultant X said:

"E-waste is one waste which is…almost everything gets recycled…except may be the low-value goods like the lamps. Today…I even now challenge you…you go to any of the dump sites in India or any of the dust-bins in India, you won't see e-waste lying there. Even if you want, you throw your e-waste into the dust-bin…within like 15-20 minutes it will be taken away by somebody because there is value in it. Whereas bulbs and all that don't have value, again cells

don't have much value…so, it remains in the dust-bin. But, otherwise almost all the other e-waste…it gets recycled." – (#9).

But, where there is a market for such cells (small batteries) and bulbs, these are picked up and they get into the reverse supply chain. For example, Co-founder of RWM spoke about rag-pickers picking up low-value items that has a market: *"pencil cells go in a garbage bin...but, these rag pickers pickup from this garbage bin and they have this collection of some 10 kg of cells...and they will come and give it to a scrap dealer.", "you can just visit any of these dump yards...in dump yards you will see those rag pickers just moving with long sticks and they also have a magnet in the front of their sticks and they keep hunting for anything of smallest possible value"* – (#54) [Role of scrap metal supply chain].

Low margins are the main reason why many Processors (based in South India) refuse to take CFLs, bulbs, and other lamps from consumers. This is because glass recyclers are dominantly present in Moradabad. Processors in Karnataka and other South Indian states need to incur high transportation costs to transport the collected lamp items to Moradabad and their margins do not work out. Thus, 'frictions' in the market prevents a trade from being executed.

These are evident from comments #5, #9, #54[Role of scrap metal supply chain], #22, #129, #105, #157, #159.

<u>Importance of manual disassembly in e-waste processing</u>

Maximum value (i.e. resource recovery) can be obtained from e-waste processing only through manual disassembly. For doing repair-cum-refurbishment, cannibalization, and disassembly into commodities, manual method is the most appropriate. Automation (i.e. using machinery to disassemble e-waste into commodities) requires high quantity of e-waste (more than 10,000 MT per annum). After crushing the e-waste, automation separates ferrous components using magnetic separators. Non-ferrous components passes through eddy currents to get separated into the metal streams like copper, aluminium, etc. But, the yield will have high impurity i.e. copper can get into aluminium and aluminium can get into copper. Due to this impure yield, the price that one gets for the commodity is low. Manual method is suitable if the facility is operating at around 500-2000 MT per annum and expenses are also low when compared to automation. Founder of RTH said about advantages of manual method:

"Physical separation [i.e. using manual labor] is the best because of when you dismantle, at that moment itself, everything gets separated...everything will be separated...metals are separated...in metals, non-ferrous is separated, ferrous is separated...in non-ferrous, aluminium, copper, brass, etc. is separated...plastic is separated...PCB is separated...MS is separated...things for disposal [to be given to TSDF] is also separated...in physical dismantling, this advantage is there...so, immediately your metal is ready to use...you just need to put that metal in furnace and start it."

Since impurities in the yield are much lower, profits are higher in manual method when compared to using automation. Founder of RTH said:

"You have installed a machine worth Rs. 10 crores...you are not getting even 500 tonne material per year...total waste...you have made this much investment...for Rs. 10 crores, you will have to pay Rs. 10 lakh interest...if you cannot make even this, business model is a fail. If you ask about my business model...in the current scenario of market of e-waste industry...physical separation [i.e. manual method] is the best way to survive...not making money...to survive." – (#62).

These are evident from comments #13, #14, #17, #18, #62, #79, #115, #118. Evidence from secondary sources also corroborates this (#140, #187, #194, #245, #370 [Role of scrap metal supply chain], #178). For example, a paper authored by Christian Hagelüken, who has 25 years' experience in Precious Metal Recovery and had held senior positions at Umicore (a Precious Metal Refiner) described the unique aspect of increasing the recovery of precious metals (Hagelüken, 2006). He reported that precious metal recovery from manually disassembled PCBs are higher when compared to precious metal recovery from machine shredded PCBs that are separated ferrous, and non-ferrous fractions using magnetic separators and eddy currents (Hagelüken, 2006). Connecting this evidence with precious metal refiners' constant search for sourcing PCBs from emerging markets (countries in Africa with a significant presence of informal e-waste processors), reveals an interesting finding (Recycling Today, 2014). Precious metal refiners prefer to source PCBs from emerging markets, to obtain manually disassembled PCBs. This helps the refiners to maximize precious metal recovery.

Theme 5: Quartz Project and the role of market mechanism

The existence of this interesting project was a surprising evidence from the field. This project (Quartz Project) was managed by STIMULUS and initiated as a CSR (Corporate Social Responsibility) activity of IMU (a Precious Metal Refiner based in Europe). STIMULUS created a conducive framework and brought Informal Processors, Formal Processor EP, and IMU to do business with each other i.e. STIMULUS facilitated market creation. Informal Processors were incentivized to sell PCBs (otherwise, they would do hazardous processing for metal recovery) to EP who would further ship it to IMU. The benefits of this supply chain was a potential reduction in negative environmental externalities and occupational diseases by diverting the hazardous metal recovery operations from Informal Processors to environmentally safe processing at IMU (in Europe). Informal Processors, EP (a Formal Processor), and IMU did trading of PCBs due to the profit motive, and in this process protected the environment and health. So, the invisible hand of market played its role and the environment was protected. This was achieved without any legislations. This market (or supply chain) resembled Coase Theorem (Coase, 1960) where STIMULUS brought together all the three stakeholders by enabling them to transact in markets (thereby reducing their transaction costs) and negative externalities were reduced. Details of this supply chain are provided below.

Evidence from the field (NVivo node: *Quartz Project*)

Consultant X said regarding this project:

"So, we brought all these players together...because, for everybody there is something win-win in it...and it is purely on economic basis...but, by doing this we would stop the leaching...that was our idea...for us, the environment objective was there." – (#1).

This project was initiated in 2010 for a period of 1.5 years and the project was monitored by the respective State Government along with STIMULUS. There are three stakeholders in the e-waste RSC who are involved in this project: Informal Processors, a big Formal Processor (i.e. EP), and IMU. The informal processors traditionally used the acid-leaching method to extract gold and silver from PCBs and they could recover only about 40% using this unsafe low-cost method. But, large precious metal refineries like IMU extracts 99% gold and silver and also extracts more types of metals. Informal Processors did not have export license, but

they could pool together the required quantity for a container (1 container has the capacity of 10 metric tonnes of boards). EP had the export license, but did not have the required quantity and had to wait for months to fill a container, so that it can be shipped to IMU (IMU was located in another country).

IMU paid EP, in advance, to pay a fixed amount to the Informal Processors upfront. As and when, these Informal Processors brought 5 kg, 10 kg or whatever quantity of boards, EP would inspect/evaluate PCBs and pay an amount immediately. Later (after 3-5 months), after IMU extracts metals from these boards, an additional amount (based on how much metals were extracted and metal prices in the international market) is paid to these Informal Processors through EP. In fact, IMU extracts 17 metals (precious and non-ferrous) from these boards. After the project period got over (in mid-2011), IMU stopped upfront payments to EP. Now, EP is paying an amount upfront to the Informal Processors and Informal-turned-Formal processors, and collecting PCBs to be shipped to IMU.

IMU has certain norms regarding how the boards should be cut, what boards to be cut, size specifications. These can be done by Informal Processors, Informal-turned-formal Processors, or EP. If Informal Processors and Informal-turned-formal Processors does not do this, EP shreds boards to required specifications and exports to IMU. Though EP does recover metals from visible parts of boards, what is being shipped to IMU are those parts from which it is hard to extract metals. This is because the normal metal recovery process (employed by EP) works only on the surface of materials (visible parts) and do not reach inside ceramic layers, interboard layers, plastic layers, etc.

<u>The existence of this supply chain supports the view that market mechanism (without any kind of Government intervention) can solve negative environmental externalities and occupational diseases associated with e-waste processing in the informal economy.</u> Once, STIMULUS facilitated markets to function, the stakeholders identified optimal trading mechanism by themselves. However, this evidence was found only for metal recovery operations.

These are evident from comments #1, #2, #4, #5, #24, #25, #33, #37, #39, #41, #51, #73, #8, #63 to #69, #94 and corroborated by evidence from secondary sources.

Theme 6: Related to EMHR

T6.1 Origins of EMHR

Prior to field work, our hypothesis was EMHR is exogenous to the e-waste RSC. But, evidence from the field revealed that some stakeholders in the RSC spent resources (for pursuing their individual agendas) to persuade the Government to formulate EMHR. The Government seems to take actions or make policies on the behalf of these select stakeholders. This phenomenon is related to the concept of regulatory capture in economics (Stigler, 1971). However, it is to be noted that this regulatory capture need not occur only through any financial or material means. Rather, it can also happen by influencing the Government's actions through writing, speaking, and publishing articles on informal e-waste processors and why the proposed legislation (i.e. EMHR) is the best possible to manage negative environmental externalities of informal e-waste processing.

Evidence from the field (NVivo node: *Origin of E-waste Rules 2011*)

(A) Influence by Formal Processors

Formal Processors had vested interests. They wanted EMHR to be enacted so that e-waste can be diverted from the Informal Processors. Formal Processors also influenced (through writing, speaking, publishing articles) the Government to bring EMHR. Products like mercury lamps, CFLs, tube lights, etc. (which are normally disposed in streets and dustbins) were not covered in EMHR (due to lobbying by lamp manufacturers) while products that were already getting recycled (ex: telecom, IT hardware, etc.) were covered in EMHR. For example, Officer at a Governmental organization said:

"E-waste Rules came only in 2011...even before introducing E-waste Rules, e-waste was being managed…people in Shivaji Nagar [in Bangalore] was doing this activity, long ago...they have been in the scrap trading business for a very long time…for generations. They used to collect scrap materials, take out valuables from these scrap and sell in the market...this business was going on, even before E-waste Rules came. Then, the big formal recyclers entered into this business...you would be knowing who those people are…they had invested significant money and built recycling facilities during the early part of last decade…they fought for the

Rules...they wanted to ensure that all MNC companies give e-waste only to them…why? Because, they knew that they could take out palladium, gold, silver, etc. from e-waste and make good money. So, they wanted E-waste Rules to come…they wanted to eliminate the informal sector, so that they can be over them and do the business." – (#5).

These are evident from comments #1, #5, #6, (#23) [Node: Other information regarding EMHR]. Evidence from secondary sources also suggests the plausibility of regulatory capture from Formal Processors (#8, #9, #25, #39, (#195) [Node: Other information regarding EMHR]).

(B) Influence of European Union

STIMULUS is an Indo-German-Swiss organization. They had played an active role to introduce EMHR by writing, speaking about the negative impacts of informal e-waste processing in India, from the year 2002-2003. They also played a major role in drafting EMHR by consulting with the Government (SPCBs, CPCB, MoEF) and Manufacturers' Association. E-waste quantity assessment (how much e-waste is generated, what type of e-waste is generated, etc.) in major cities were jointly funded by EU (i.e. funds came from the Indo-German partnership).

The concept of product take-back legislation originated in Europe (as discussed in the Literature Review). Europe has interests to "export" its environmental laws across the world, which favors their native firms (Buck, 2007a; Buck, 2007b). This "export" of environmental laws is also theorized by scholars in Political Science discipline (Selin & VanDeveer, 2006; Selin & VanDeveer, 2015a; Selin & VanDeveer, 2015b; Vogel, 2012). They have found support for their theory based on evidence from various countries across various industries including automobiles, e-waste, pesticides, etc.

With this theory in hand, one can re-interpret several events regarding formalization of informal e-waste processors and the Quartz Project. For example, IMU (a European firm) had acquired ($800 million cash purchase) the precious metal refining group of a major conglomerate in 2004. STIMULUS had started the e-waste awareness and programmes in India in 2003. By 2004, e-waste quantity assessment programmes were initiated in major Indian cities. In 2008, the top management of IMU revealed that they were not getting "enough" PCBs

to do precious metal recovery. In 2010, IMU initiated the Quartz project to source PCBs from India's informal processors. Around the same time, EMHR (product take-back legislation similar to EU's e-waste legislation) was notified in 2010 and the law was effective from 2012. It has been discussed in Theme 4 that metal recovery is highest for the precious metal refiners, when using manually disassembled (done by the informal processors in India) PCBs as raw material.

All these evidence are synthesized from comments #1, #73, #7, #42, #82, and #84 from [Node: Quartz Project]; #240 [Node: Nature of e-waste processing], #101 and #103 [Node: Any info. for formalization chapter], #18 to #21, #31, #33, #43, #44; #24, #121, #122, and #213 from [Node: Other information regarding EMHR].

Hence, based on these evidence there is reasonable confidence to develop a proposition that influence of EU existed in India's e-waste legislation (i.e. EMHR).

T6.2 Stakeholders' challenges

On one hand, the accepted wisdom is Government is not monitoring the implementation nor enforcing EMHR; Manufacturers do not comply with EMHR, etc. But, on the other hand Government and Manufacturers also have genuine operational challenges to comply/monitor/enforce EMHR. They are summarized in the tables below.

Table 75: Challenges faced by Government to enforce and monitor

Topic	Details
Loopholes in EMHR	- MSMEs not included in EMHR; Many Formal Processors also full under MSMEs because their investments are < 2 crores - Ambiguity (ex: branded phones are also imported by many dealers; so, whom to approach for enforcing? These numerous dealers or the original manufacturer)
Inherent difficulty to enforce and monitor	- E-waste Processors are not like the continuous processing plants where a sample can be collected from the chimney (or other discharge points) and tested if it falls within prescribed limits - E-waste processing is intermittent (does not happen every day) and dry (except metal recovery operations) - Inability to assess/analyze how much commodities can be extracted from the heterogeneous e-waste; have to believe whatever the Processors say
Lack of resources to enforce and monitor	- Severe shortage of staff (inspectors and support staff)

	- Number of firms increase every year, but corresponding number of staff are not recruited; Single inspector in-charge of one jurisdiction with 2000 firms, cannot enforce/monitor 15+ legislations (for each firm) in a year.
Political economy of punishing, penalizing stakeholders for non-compliance	- Protocol of Court proceedings needs to be followed; SPCB cannot close down a firm saying that it is not complying with EMHR - Manufacturers are also equated with higher revenues for Government and employment for citizens; not possible to close down a Manufacturer saying he does not comply with EMHR - Political connections of Manufacturers/Bulk Consumers pressurize the SPCB or inspectors not to take action - Powerful big firms (in other industries) continue to pollute and SPCB cannot take any action; when compared with them, there is negligible pollution from e-waste Processors - When powerful big firms get away, it is not reasonable to punish small-scale Informal Processors (because, it is a livelihood for them)

Table 76: Challenges faced by Manufacturers to comply with EMHR

Topic	Details
Low margins in electronics manufacturing industry	- Wafer thin margins per product; Many Manufacturers have shut down their manufacturing plants
Lack of existing infrastructure for general waste management	- India does not have a good last-mile collection network for general waste management, when compared to other developed countries - Manufacturers are able to set-up collection systems in developed countries because they already have good existing last-mile collection network for general waste management; This is why Manufacturers comply with take-back laws in developed countries
Investment in collection centers are not worth the efforts	- Retail Consumers do not return their products in collection centers; they prefer to sell to Door-to-Door collectors - Not sustainable to give monetary incentives to Retail Consumers to return their products; Offering monetary incentives creates a wrong mind-set and the focus would shift from environmental/societal goals - When Manufacturers offered monetary incentives to Retail Consumers, informal economy (consisting of Scrap Traders/Informal Processors/Dealers in second-hand market) offered higher amount than Manufacturers; impossible to compete with the informal economy - Setting up collection centres needs investment and patience to go through Governmental bureaucracies; But, the quantity of e-waste collected in these centers are too low to justify the investment/efforts
Nature of e-waste	- Heterogenous nature of e-waste (mix of positive and negative salvage value products) pose challenges for collective producer responsibility
Less time given to comply with EMHR	- EMHR had a life for only 1.5 years; this time was majorly spent to resolve ambiguities in EMHR and Governmental bureaucracies to set-up collection centers

T6.3 Stakeholders gaming the system

Though this was discussed briefly as part of Proposition 18, this is described in detail in this section. While doing this research, field evidence revealed that stakeholders in the e-waste RSC

game the system. This included two scenarios: (1) gaming the system to override E-waste Rules i.e. stakeholders comply with EMHR on paper. But, in reality they flout EMHR. (2) Gaming the system irrespective of any kind of legislation of EMHR (due to the nature of this industry).

This phenomenon of stakeholders gaming the system is related to an economics concept known as rent seeking. This concept refers to the purposeful activity by individuals/organizations to seeking ways to shift profit (also called as "rents" or wealth) toward oneself or a favoured group through the use of the Government (Tullock, 1967; Kreuger, 1974). Our objective, here, is to briefly introduce the idea behind this concept. Theoretically speaking, stakeholders gaming the system is not the same as rent seeking. However, it is worthy to mention this concept as it is somewhat related to "gaming the system".

Evidence from the field (NVivo node: *Stakeholders gaming the system*)

(A) Trading licenses

Informal Processors takes the license of Formal Processors and purchases e-waste from Bulk Consumers. These Informal Processors processes this e-waste in unsafe/unscientific ways and pays a fee to the Formal Processor from whom he has taken the license.

(B) Transaction between Bulk Consumers and Formal Processors

All Formal Processors have a passbook provided by the Government. This passbook should have details of e-waste purchase (i.e. from which Bulk Consumer? how much e-waste was purchased? When?) and e-waste disposal (i.e. disassembled commodities are disposed to whom? How much? When?). Bulk Consumers do not prefer to affix their seal on this passbook. Sometimes, Bulk Consumers sell a significant portion of their e-waste (preferably high economic value e-waste) to Informal Processors and the rest (preferably low economic value to Formal Processors). So, on paper Bulk Consumers always show that they have disposed to Formal Processors. For doing all these, Bulk Consumers also fudge the quantity of e-waste generated.

(C) Formal Processors

Formal Processors do the following:

- Formal Processors who does metal recovery purchase PCBs from the Informal Processors/Scrap Traders
- Sell some portion of e-waste purchased (that can be reused, repaired-cum-refurbished, cannibalized) to Dealers in the second-hand market
- Sell a portion of the purchased e-waste to Informal Processors
- Not disposing hazardous by-products of e-waste processing and unprocessed parts to TSDFs
- Fudging accounts to conceal the above activities
- Running showroom factories i.e. employees use pollution abatement technology and protective equipment only during the time of inspection or client visits

(D) Interface with the Government

- Bulk Consumer and PCMs are told by officials from respective SPCBs to dispose to particular Formal Processors. Sometimes, even the price is decided by the officials. Formal Processors pay a fee to the officials and Bulk Consumers/PCMs escape from their violations of environmental laws or receive favouritisms for other business decisions.
- Pleasing Government officials or Ruling political parties to start a formal e-waste processing facility
- Nexus between Politics, Business, and Government

When we say that stakeholders game the system, we do not mean to say that "all of them" in the industry do this. Rather, many stakeholders do this and some stakeholders do not do this.

Theme 7: Path Dependence

This concept (i.e. path dependence) emerged from field evidence. In a simple way, this concept means *History Matters*. The e-waste RSC is path dependent i.e. the e-waste RSC that exists is a function of several historical events. Liebowitz & Margolis (2000) defined this concept as follows: "Path dependence means that where we go next depends not only on where we are now, but also upon where we have been. History matters." Various facets of path dependence manifested in the e-waste RSC are summarized in Table 77.

Table 77: Facets of path dependence in the e-waste RSC

Facets of path dependence	Details
Informal economy	- History of informal economy in every industry (post-consumer waste recycling, media, dairy, healthcare, electronics manufacturing, publishing, etc.); this presence of dual economy is a characteristic of countries like India. - Presence of informal economy in industries associated (downstream) with e-waste (e.g., scrap metal smelting, electroplating, plastic products manufacturing, components manufacturing, second-hand markets, etc.) - Consider a part of the e-waste RSC, after e-waste leaves the Formal Processor and goes through formal economy: metal traders => alloy manufacturers => component manufacturers => PCMs. For this chain with 4 stages, there is a parallel chain in the informal economy with the same 4 stages: informal metal traders => informal alloy manufacturers => informal component manufacturers => informal or formal PCMs. Sometimes, these two parallel chains intersect. - Scholars in sociology have extensively studied and documented this presence of dual economy in India in various industries.
Metallurgical knowledge	- Ancestral origins of metal recovery operations of informal e-waste processors in Bangalore, can be traced back to gold recovery from mill-tailings from gold mines - Areas surround Delhi (particularly Moradabad) are the hub of metal recovery from PCBs; this knowledge has potentially come from internationally renowned metal crafts industry that has been existing from 17th century in Moradabad. - Mining metals from ores, melting them, alloying them with other metal for improved properties, and collecting & melting scrap metals were prevalent during the Harappan Phase of the Industry Valley Tradition (2600 – 1900 BC) - India's rich history in the science of metallurgy: Iron Pillar at Delhi, Wootz steel, Beams at Konark's Sun Temple are outstanding achievements recognized by metallurgy scholars across the world - World's No. 1 Precious Metal Refiner had publicly stated that its roots in mining & metallurgy had helped them to become leaders in metal recovery. This also corroborates as to why informal processors have been experts at metal recovery from e-waste.
Embeddedness	- Firms and their interrelationships in the informal scrap metal (commodity) supply chain (including e-waste RSC) are characterized by "embeddedness" - Economic activities are "embedded" in kinship and religious communities

	- Scholars specializing in the sociology of Indian economy, have also pointed out the relation between religion and occupations. It is not by a random occurrence that one can find a large presence of Muslims in e-waste processing industry. Similarly, there are other religious or ethnic communities (ex: Marwari Hindus) involved in plastic recycling, scrap metal smelting (commodity recycling), etc.
Scrap metal supply chain	- E-waste RSC is a small cog in the big wheel of centuries-old scrap metal supply chain - E-waste RSC is an off-shoot of the scrap metal supply chain that was existing for a very long time (over 100 years) - Before e-waste started joining the waste stream in early 1990s, this supply chain existed not only for scrap metals, but also for plastics, glass and other commodities; the metals from e-waste entered the scrap metal supply chain and other commodities like plastic, glass entered the respective commodity supply chain

Towards a suggestive model for understanding the e-waste RSC

Based on the evaluation of these 18 propositions and emergent themes (i.e. Theme 1 to Theme 7), the initial conceptual framework is refined to provide a suggestive model for understanding the e-waste RSC. A list of revised propositions and emergent themes are summarized in Table 78. The refined conceptual framework to understand e-waste RSC is illustrated in Figure 16.

Table 78: Summary of revised propositions

No.	Original Proposition	No.	Revised Proposition
1	Sources of e-waste are Retail Consumers, Bulk Consumers, and PCMs having different purchase and disposal mechanisms.	1	There are four sources of e-waste: Retail Consumers, Bulk Consumers, PCMs, and Imports.
2	Retail Consumers purchase from retailer channels (on-line and off-line) at maximum retail prices in small quantities.	2	Retail Consumers purchase from e-commerce stores (online) and brick-and-mortar stores (offline) at maximum retail prices in small quantities.
3	Bulk Consumers purchase from dealers, authorized by manufacturers/importers, in large quantities through some contracts.	3 a)	Bulk Consumers purchase from manufacturers and authorized dealers in large quantities through contracts
		b)	Bulk Consumers also purchase from authorized dealers in small quantities through contracts
		c)	Bulk Consumers pay less than maximum retail prices
		d)	Bulk Consumers located SEZs import e-products without paying import duty and these products remain bonded with them after use
4	Manufacturers of electrical and electronic products produce defective products that enter e-waste stream.	4 a)	Manufacturers that exist along the forward supply chain of e-products (i.e. PCMs) generate e-waste.
		b)	This e-waste consists of products, components, and waste by-products during manufacturing.
		c)	The disposed products and components can be functional or non-functional.
5 a)	The economic value of products discarded by consumers (retail and bulk consumers) depends on its functionality, demand in second-hand market, design modularity.	5 a)	Economic value of discarded products depends on its functionality, demand in second-hand market, brand origin, commodities inside, and salvage value.
b)	Functional products have higher economic value than non-functional products.	b)	Functional products have higher economic value than non-functional products.
c)	Functional products with high demand in second-hand market have higher economic value than functional products with low demand in second-hand market.	c)	Functional products with high demand in second-hand market have higher economic value than functional products with low demand in second-hand market.
d)	Products with high design modularity have higher economic value than products with low design modularity.	d1)	Functional products with high design modularity have higher economic value than functional products with low design modularity.
		d2)	Products with high design modularity have lower commodity value than products with low design modularity.
		e)	Functional products of foreign brands have higher demand in second-hand market when compared to functional products of domestic brands.

		f)	Some products have positive salvage value, while some products have negative salvage value.
		g)	Processors have incomplete information regarding yield of commodities from e-waste and market knowledge of commodities inside e-waste.
6 a)	Retail consumers have six options to dispose e-waste: stock-up at home, sell to door-to-door collectors, sell to retailers, give to formal processors, return to manufacturers, or combine with municipal solid waste.	6 a)	Retail consumers have nine options to dispose e-waste: stock-up at home, sell to Door-to-Door Collectors, sell to Retailers, give to Formal Processors, return to Manufacturers, combine with municipal solid waste, gift to other Retail Consumers, sell to other Retail Consumers, donate to Bulk Consumers.
b)	Low volume products with low economic value are stocked-up at home or disposed along with municipal solid waste.	b1)	Low volume products with low economic value are disposed along with municipal solid waste.
		b2)	Low volume products with high perceived economic value are stocked-up at home.
c)	Low volume products with high economic value are stocked at home or sold to retailers.	c1)	Low volume products with high economic value are stocked-up at home or sold to retailers.
		c2)	High volume products with high economic value are exchanged with retailers.
		c3)	Low volume products with high perceived economic value are stocked-up at home.
d)	High volume products with high economic value are sold to door-to-door collectors or retailers.	d1)	High volume products with high economic value are sold to door-to-door collectors or sold to retailers or donated.
		d2)	High volume products with high economic value are also stocked-up, waiting for Door-to-Door Collectors.
7 a)	Bulk consumers have six options to dispose e-waste: stock-up at warehouse, conduct auctions, contract with scrap traders, contract with formal processors, return to dealers, or combine with municipal solid waste.	7 a1)	Bulk Consumers have eight options to dispose e-waste: stock-up at open yards and closed rooms; conduct auctions; sell to scrap traders; sell to Formal Processors with or without long-term contracts; return to manufacturers or exchange with dealers; dispose along with municipal solid waste; donate to organizations; sell to employees.
		a2)	Bulk Consumers dispose e-waste through IT and Admin Departments separately

		a3)	Technological change influences Bulk Consumers' e-waste disposal. Higher rate of technological change would lead to higher frequency of e-waste disposal.
		a4)	Bulk Consumers' purchase mechanism influence their disposal mechanism
		a5)	Finance Department plays an important role in e-waste disposal
7 b)	Products with low economic value are stocked at warehouses or disposed along with municipal solid waste; products with high economic value are auctioned openly or contracted with scrap traders.	7 b1)	Products with high economic value are sold to Processors by conducting auctions or otherwise
		b2)	Products with low economic value are stocked-up or sold to Processors or disposed along with municipal solid waste
8	PCMs destroy their defective products to prevent it from entering the market and then sell to scrap traders.	8 a)	PCMs dispose e-waste to Informal and Formal Processors
		b)	Some PCMs mandates Processors to physically destroy their defective products on-site to protect their intellectual property
9	Retailers collect functional and non-functional products only from retail consumers through buy-back and exchange schemes.	9 a)	Retailers collect functional and non-functional products from retail consumers
		b)	Some Retailers give cash, some have exchange offers or trade-in programs.
10	Retailers and dealers sell e-waste only to scrap traders because they receive higher payment.	10	PCMs, Retailers, Waste Pickers, and Door-to-Door Collectors sell e-waste to Scrap Traders
11	Scrap traders aggregate the collected e-waste up to an appropriate quantity and sell them to informal processors.	11 a)	Scrap Traders collect and aggregate e-waste and sell them to Informal Processors.
		b)	The definition of Scrap Traders and Informal Processors is fluid. Scrap Traders can play the role of Informal Processors and vice-versa.
12	Manufacturers with take-back systems/collection systems sell the collected e-waste to formal processors; manufacturers do not own e-waste processing facilities.	12 a)	Manufacturers with take-back systems/collection systems sell the collected e-waste to Formal Processors; manufacturers do not own e-waste processing facility.
		b)	Manufacturers may cannibalize functional parts that can be used in their service centers, before selling to Formal Processors.
		c)	Manufacturers outsource collection and processing to Formal Processors.
		d)	Manufacturers also outsource collection to Door-to-Door Collectors who further sells the collected e-waste to Formal Processors for processing.

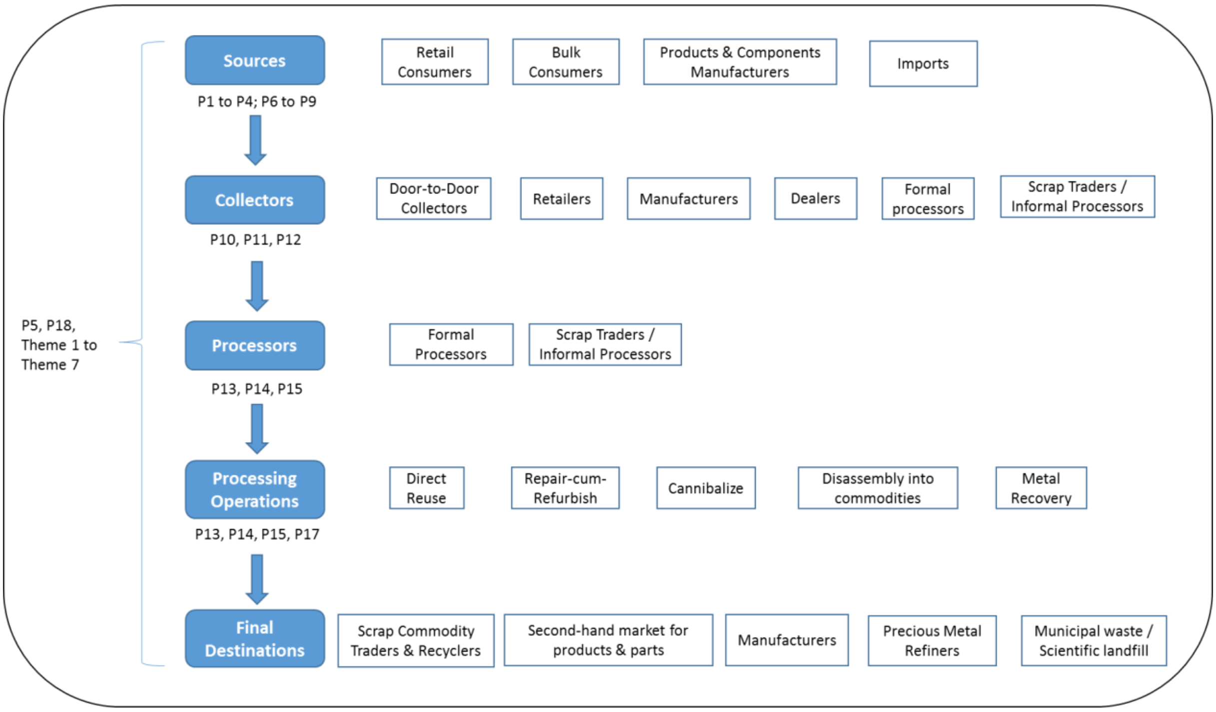
		e)	Manufacturers do not prefer to refurbish their products and sell in the second-hand market with warranty.
13 a)	Informal and Formal Processors have five options for processing e-waste: direct reuse, repairing, refurbishing, cannibalization, and recycling.	13 a)	Informal and formal processors have five options for processing e-waste: direct reuse, repairing-cum-refurbishing, cannibalization, disassembly into commodities, and metal recovery.
b)	Functional products having high demand in second-hand market are directly reused and sold to channels in second-hand market; functional products having low demand in second-hand market are cannibalized or recycled.	b1)	Functional products having demand in second-hand market are directly reused (i.e. sold in the second-hand market); But, this is moderated by prevailing contracts with Bulk Consumers
		b2)	Functional products having low demand in second-hand market are disassembled into commodities
c)	Non-functional products with high design modularity, high demand in second-hand market, and whose functionality can be restored are repaired or refurbished.	c)	Non-functional products having high demand in second-hand market and whose functionality can be restored are repaired-cum-refurbished.
d)	Repairing is preferred for low functionality loss and refurbishing is preferred for high functionality loss.	d)	-Could not be evaluated-
e)	Non-functional products with high design modularity and whose functionality cannot be restored are cannibalized for using its parts as spares or inputs to other products.	e1)	Non-functional products whose functionality cannot be restored are cannibalized.
		e2)	Functional products with low-demand in second-hand market or due to prevailing contracts with Bulk Consumers are cannibalized.
		e3)	High rate of technological obsolescence leads to low level of cannibalization
f)	Functional products with low design modularity and low demand in second-hand market are recycled; functional products with high design modularity and low demand in second-hand market are cannibalized.	f1)	Functional products with low demand in second-hand market are disassembled into commodities if its parts does not have demand in the second-hand market.
		f2)	Functional products with low demand in second-hand market are cannibalized, if its parts have demand in the second-hand market.
g)	Non-functional products with low design modularity and high demand in second-hand market are recycled.	g)	-Could not be evaluated-
h)	Unprocessed portion of products is disposed in landfills.	h1)	Informal processors dispose non-recyclable material in the open, probably joining along with municipal solid waste.
		h2)	Formal processors dispose non-recyclable material to TSDFs by paying them money.

		h3)	Certain materials can be recycled, if there are appropriate markets. Those materials that does not have a market ends up in landfills or with TSDF.
		i1)	Products with integral designs are difficult to repair-cum-refurbish, cannibalize, and are disassembled into commodities.
		i2)	Products with integral designs are difficult to disassemble when compared to products with modular designs.
		i3)	Products with integral designs have higher commodity value when compared to products with modular designs.
14 a)	A single processor (informal or formal) does all the five processing operations: direct reuse, repairing, refurbishing, cannibalization, and recycling.	14 a1)	A single processor (informal or formal) does not do all the five processing operations: direct reuse, repairing-cum-refurbishing, cannibalization, disassembling into commodities, and metal recovery.
		a2)	Processors focus majorly on one or two processing operations.
		a3)	Processors involved in metal recovery, recovers only the easy-to-extract metals; Metal recovery of difficult-to-extract metals are done by Precious Metal Refiners outside the country.
14 b)	Processors (informal or formal) do selective recycling operations.	14 b1)	Processors (Informal or Formal) do selective metal recovery.
		b2)	Processors (Informal or Formal) do not involve in end-to-end commodities recycling.
14 c)	Informal processors incur lower costs and produces lower quality output when compared to formal processors.	c1)	Informal Processors incur lower costs when compared to Formal Processors.
		c2)	There is no conclusive evidence to claim that Informal Processors produce lower yield and purity during metal recovery operation, when compared to Formal Processors.
15	Negative externalities are created by informal processors during the five processing operations on all types of products and landfilling; formal processors do not create negative externalities during the five processing operations on all types of products and landfilling.	15 a)	Formal processors minimize occupational diseases during disassembly, metal recovery.
		b)	Informal processors create occupational diseases during disassembly, metal recovery.
		c)	Formal processors minimize negative environmental externalities during disassembly, metal recovery.

		d)	Informal processors create negative environmental externalities during disassembly, metal recovery.
		e)	Formal processors minimize negative environmental externalities during landfilling.
		f)	Informal processors create negative environmental externalities during landfilling.
		g)	Other stakeholders, in the upstream and downstream, also create negative externalities.
16	Retailers, dealers, manufacturers, informal processors, formal processors, scrap traders, secondary smelters are individual profit-maximizing stakeholders in the e-waste RSC.	16 a)	Definition of Scrap Traders and Informal Processors are fluid.
		b)	There is two way interaction between Formal Processors and Informal Processors.
		c)	Retailers, Dealers, Manufacturers, Formal Processors, Commodity Recyclers are separate stakeholders.
17	The e-waste RSC structure is decentralized and open-loop.	17 a)	The e-waste RSC structure is not strictly decentralized. The processing stage and final stages of e-waste RSC has different levels of decentralization. Final stage is more centralized than the processing stage.
		b)	The concepts of decentralization and open-loop needs to be considered as a continuum.
		c)	The e-waste RSC structure tends more towards open-loop.
		d)	After being processed (by Processors), e-waste goes to commodity scrap traders, commodity recyclers, second-hand market dealers, and manufacturers.
18	EMHR has not caused significant changes in the e-waste RSC. There may be some links in the RSC that were created or destroyed after May 2012.	18 a)	EMHR modified the structure of RSC: new links were created.
		b)	Though EMHR modified the RSC structure, old links persist due to stakeholders' non-compliance and gaming the system.
		c)	EMHR created a livelock in the e-waste RSC.
		Theme 1	Tacit Knowledge in the informal economy

		Theme 2	Role of Technological Change in the e-waste RSC
		Theme 3	Influence of international commodity prices
		Theme 4	Nature of the e-waste processing: Timing and Quantity of e-waste supply are not predictable; E-waste consists of heterogeneous products and keeps varying; Nothing is a “waste”, if there is a market for it; Importance of manual disassembly in e-waste processing.
		Theme 5	Quartz Project and the role of market mechanism to reduce negative environmental externalities and occupational diseases
		Theme 6	EMHR: Its origins; Government and Manufacturers face unique challenges; Stakeholders game the system and comply with EMHR
		Theme 7	E-waste RSC is path dependent

Figure 16: Revised conceptual framework to understand e-waste RSC



Key findings of this study

Each revised proposition and emergent themes are key findings in itself. However, some salient high-level findings of this study on e-waste RSC are presented below:

a) E-waste RSC is characterized by path dependence and embeddedness (vide Theme 7 in Chapter 5 and Theme 2 in Chapter 4). This could be one reason why EMHR created a *livelock* in the e-waste RSC (vide Proposition 18 in Chapter 5). As discussed in Theme 7 (Chapter 5), e-waste RSC is *only* a small cog in the big wheel of centuries-old scrap metal supply chain.

b) E-waste RSC is market-driven i.e. there are various types of market forces that drive this industry (ex: international commodity markets, technological change, economic value of products). Stakeholders in this RSC are price-takers and not price-setters.

c) Interestingly, e-waste RSC is also characterized by a concept called spontaneous market emergence (Fafchamps, 2002). There is a spontaneous emergence of markets when there is a demand for any commodity or part inside e-waste (vide Theme 4 in Chapter 5). For example, if there were glass recyclers in Bangalore, there would be a market for glass disassembled from e-waste. This would mean that e-waste processors could sell the disassembled glass in the market.

Chapter 6: Findings and implications for public policy

In Chapter 4 and Chapter 5, 30 propositions were revised and 10 emergent themes were discussed. These propositions and emergent themes conceptualized the phenomenon (i.e. formalization, e-waste RSC) from messy details to abstract concepts. In this chapter, we integrate the conceptualization and findings from Chapters 4 and 5 to answer the research question of finding appropriate incentive schemes for encouraging formalization of informal e-waste processors. Then, we discuss implications of our findings for public policy.

Thus, this dissertation has three levels of analysis: *Level 1*- propositions & emergent themes (Chapters 4, 5), *Level 2*- findings (Section 6.1), and *Level 3*- implications for public policy (Section 6.2). These three levels are sequential (Level 1 => Level 2 => Level 3) and builds on top of one another (like a sandcone) i.e. Level 3 cannot be understood without Level 2 and Level 1; findings explained in Level 2 (Section 6.1) are based on the propositions and themes described in Level 1. Before discussing the Level 2 findings, we summarize the key findings from Level 1 analysis as follows:

a) Merely formalizing the informal processors does not reduce environmental externalities and occupational diseases. This reduction depends on voluntary adherence to formalization standards.
b) The simplistic assumption that formalization would help informal processors to process more e-waste efficiently due to scale economies is falsified through this field study. This is due to higher costs and lower revenues. Formalization has not changed the fundamental business model of informal-turned-formal processors.
c) Some Joint Proprietors of informal-turned-formal firms have quit and returned to work in the informal economy due to lack of profits in the final stage. For example, Informal Processor A was initially a part of Alpha; Informal Processor B was initially a part of Gamma.
d) It is important to recognize the contingent characteristics (ex: embeddedness, minimalist way of life) of informal processors in this discussion/debate on formalization.
e) E-waste RSC is characterized by path dependence and embeddedness. This could be one reason why EMHR created a *livelock* in the e-waste RSC. As discussed in Theme 7 (Chapter 5), e-waste RSC is *only* a small cog in the big wheel of centuries-old scrap metal supply chain.

f) E-waste RSC is market-driven i.e. there are various types of market forces that drive this industry (ex: international commodity markets, technological change, economic value of products). Stakeholders in this RSC are price-takers and not price-setters.
g) Stakeholders in the informal economy possess tacit knowledge for appropriately (i.e. for maximum resource recovery) processing e-waste. This knowledge is acquired through inheritance and apprenticeship-based training.
h) E-waste RSC is characterized by a concept called spontaneous market emergence (Fafchamps, 2002). There is a spontaneous emergence of markets when there is a demand for any commodity or part inside e-waste.

6.1 Findings

(A) Alignment of operational configuration of processors with the nature of industry

From the perspective of e-waste Processors (Formal or Informal), nature of e-waste processing industry suggests the following characteristics:

i. Timing, quantity, and type of e-waste supply is irregular, unpredictable.
ii. E-waste consists of heterogeneous product mix (i.e. different types of products ranging from mobile phones to complex telecom towers and servers).
iii. The amount of yield (i.e. content of commodities) within each product is uncertain due to technological change and other external factors. In many cases, technological change has reduced the recovery value from e-waste.
iv. Profits are dependent on movements in the international commodity markets.

These are evident from Themes 2, 3, & 4 in Chapter 5; Proposition 12, Theme 3 in Chapter 4.

Given the nature of this industry, the best possible operational configuration for a typical e-waste Processor (Formal or Informal) consists of the following:

✓ Low costs: Ability to operate at low fixed costs and variable costs.
✓ High flexibility: Ability to process different types of e-waste (heterogeneous product mix), whenever it is available, at whatever quantity; Ability to employ hire-and-fire labor.

- ✓ High quality[43] of operations: Ability to recover maximum value from e-waste through direct reuse, repair-cum-refurbish, manual disassembly into commodities (job-shop type operations).
- ✓ Quick turnaround time (high inventory turns): Ability to disassemble e-waste and sell revenue generating recyclables in the market *as quickly as possible* by carrying zero or minimal inventory. This significantly reduces inventory holding costs.

Cost and flexibility would be the top-most priority followed by quality and processing time. *Surprisingly, Informal Processors' operational configuration is aligned with the nature of this industry*. *Formal Processors' configuration for processing e-waste is not aligned with the nature of this industry and is characterized by high costs and low flexibility*. In essence, Informal Processors are superior to Formal Processors in all these 4 dimensions: low cost, high flexibility, high quality, and quick turnaround time[44]. The logic of this finding is arrived at primarily through Propositions 1, 7, 11 and Themes 1, 2, 3 from Chapter 4; Theme 4 from Chapter 5. <u>*When informal processors formalize and become formal, alignment of their operational configuration with the nature of this industry is lost!*</u> The business challenges faced by informal-turned-formal processors (described in Theme 1, Propositions 7(e), 11 from Chapter 4) are symptoms of the lack of this alignment. Formal Processors also regularly complain regarding low profit margins, lack of sufficient e-waste to run their processing facilities, low capacity utilization, etc. These are also symptoms of the lack of this alignment. For example, Business Development Manager of CIT (a formal processor) said:

"E-waste supply is not steady. We cannot afford to staff labor daily. Hence, we accumulate the material to a certain level and call labor for dismantling." – (#76) [Nature of e-waste processing]. In this snippet, one could observe low flexibility of the Formal Processor.

Consultant X said about the Proprietor of Beta (informal-turned-formal processor), as follows: *"Before formalization, he used to say: 'we get 2000 rupees per day and we work for 5 days or so a month. That is enough for us. Why do we need more money?' But, after formalization he says: 'from where can I get more e-waste? I need to run my plant at full capacity. I need to*

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[43] Quality does not denote the product quality. Rather, quality denotes the ability to recover maximum economic value from e-waste.

[44] A detailed explanation for this observation (i.e. ability of informal processors to excel on all the 4 dimensions) is provided in Appendix 8. To explain this, we use the concept of performance frontiers.

feed my 10 employees. We need to run the plant everyday'. This is a stark difference I have noticed in him. This difference is due to the formalization of his business." – (#133) [Nature of e-waste processing]. In this snippet, one can explicitly notice the break in alignment when Beta became formal.

Proprietor of Delta (informal-turned-formal processor) said: *"Where is it [e-waste] going? Why are we not getting? We are following Government's rules...so, Government should also do something for us: 'he is working properly...we will help him get material'...nothing like this is there. We put in lots of efforts to make certificate...and we are putting in lots of efforts to get material too...we could have done this in the informal too...in informal also, we were doing the same thing...now also, we are doing the same thing...<u>what is the benefit of becoming formal</u>? This is one big thing...we were happy in the informal too...now, we have become formal...see, <u>if we go home and sleep, we keep thinking about the monthly rent, labor charges...these kind of tension were not there before</u>...bring material, hire 4 laborers for 4 days, do the work, finish the work, then go and bring another material...it was like this...now, only if you give work continuously, laborers will stay with us...if you give work for 4 days and do not give work for another 4 days, how will laborers stay with us? I have to sit and work myself."* – [Node: Interesting quotes, perspectives from Formalization chapter]. In this snippet, one can explicitly notice the break in alignment when Delta became formal.

Before formalization, the processing operations were aligned with the nature of this industry. But, after becoming formal, this alignment was lost. After becoming formal, "low cost" became "high cost", "high flexibility" became "low flexibility". This break in alignment between operational configuration and the nature of industry is what lies underneath, when Informal-turned-formal Processors spoke about the operational challenges (explained in Propositions 7(e), 11, and Theme 1 from Chapter 4) after becoming formal. Only those Informal-turned-formal Processors, who were able to ensure steady supply of good quantity e-waste, are performing well (e.g., Delta).

Evidence from secondary sources also provide support for our theory regarding high levels of flexibility available with the Informal Processors. For example, a 2009 report by an NGO (Chintan Environmental Research and Action Group, 2009) described how Informal Processors in East Delhi responded to the scrap market crash during 2008 recession:

"…some shops began to work only part time, and others shut shop. It was not possible to get an accurate estimate of how many in each category. The workers in this area began to drive auto-rickshaws, and serve the local population, predominantly poor, with ferrying services till the main roads. We estimate that they were able to earn minimum wages, since the area is large, densely populated but very poorly connected…" - (#184) [Nature of e-waste processing].

Here, a discerning researcher could observe the high labor and occupational flexibility prevalent in the informal economy. It would be unimaginable to see a Formal Processor respond to the scrap market crash in this manner.

Though it was surprising for us to find that Informal Processors' operational configuration (with low-cost rudimentary/unsafe processing operations using manual method, run by close-knit community of semi-literate people) aligns with the nature of this industry, it is *actually* not *that* surprising. Take the case of Mumbai Dabbawala's lunchbox delivery system that is low-cost, simple, and efficient (Thomke, 2012)[45]. This delivery system (manual method of coding and assigning lunchboxes by semi-literate people, cycle-based transport, close-knit community) is aligned with the particular nature of the industry (Mumbai's landscape, metro train network, customers' preference for home cooked food, primarily serving non-elite middle-class and lower-middle class customers with modest ability to pay). This alignment would break if their delivery system is replaced with high-tech equipment for bar coding or using smartphones, motored vehicles for transport, etc. (Thomke, 2012). If Mumbai Dabbawal's delivery system was useful to theorize on best practices in logistics & supply chain management, Allahabad's Maha Kumbh Mela (a religious festival that happens once in 12 years) has been used to theorize on best practices to organize service delivery in rapidly urbanizing cities or mass refugee campus. One of the major focus of the 2013 field study of Kumbh Mela was to understand organization of service delivery (i.e. spontaneous emergence of markets in transport, housing, food and other essentials) to the 30 million people over the five weeks of festival (Khanna, 2013). The key finding of this study was this: Maha Kumbh Mela 2013 (run by citizens and Government officials, who are non-professionals) was better organized than the professionally run 2014 FIFA World Cup and 2010 Commonwealth Games (Mishra, 2015). Hence, it is *actually* not *that* surprising to find Informal Processors' operational

[45] We thank the Co-founder of RWM, who used this analogy of Mumbai Dabbawala to explain the operations of informal economy in e-waste processing.

configuration better aligned with the nature of e-waste processing industry when compared to Formal Processors.

By theorizing about alignment between operational configuration and nature of the industry, we are not ignoring the negative environmental externalities and occupational diseases prevalent in Informal Processors. Having recognized the alignment issue, our next focus would be to address this question: *How to incentivize informal e-waste processors to adopt safe, scientific methods and become part of the formal economy, by preserving this alignment*? This is discussed in the section on implications for public policy.

(B) Contribution to the Theory of Product Take-Back Legislation

Extant theorization on E-waste Product Take-Back Legislation has focused on developed markets. This study, focused on an emerging market (India) has brought attention to several concepts / moderating factors ignored in the extant literature. This is illustrated in the figures below.

Figure 17: Knowledge of the phenomenon, before fieldwork

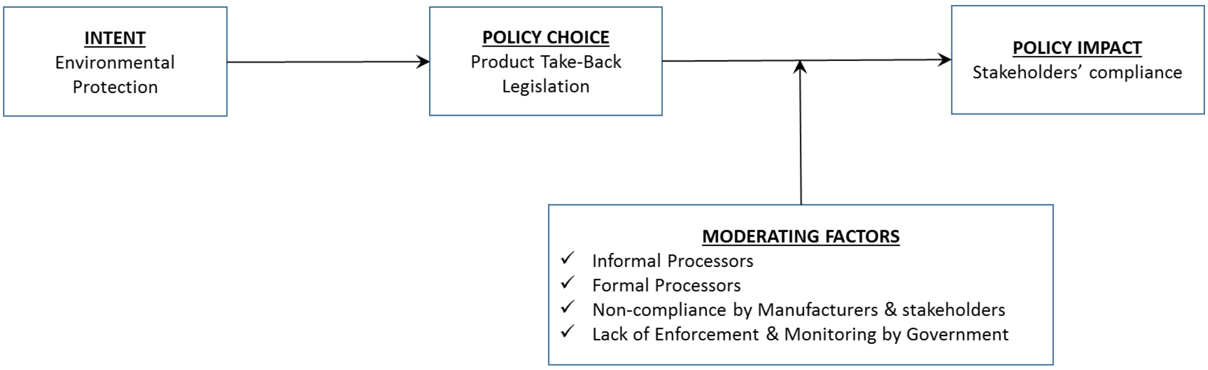
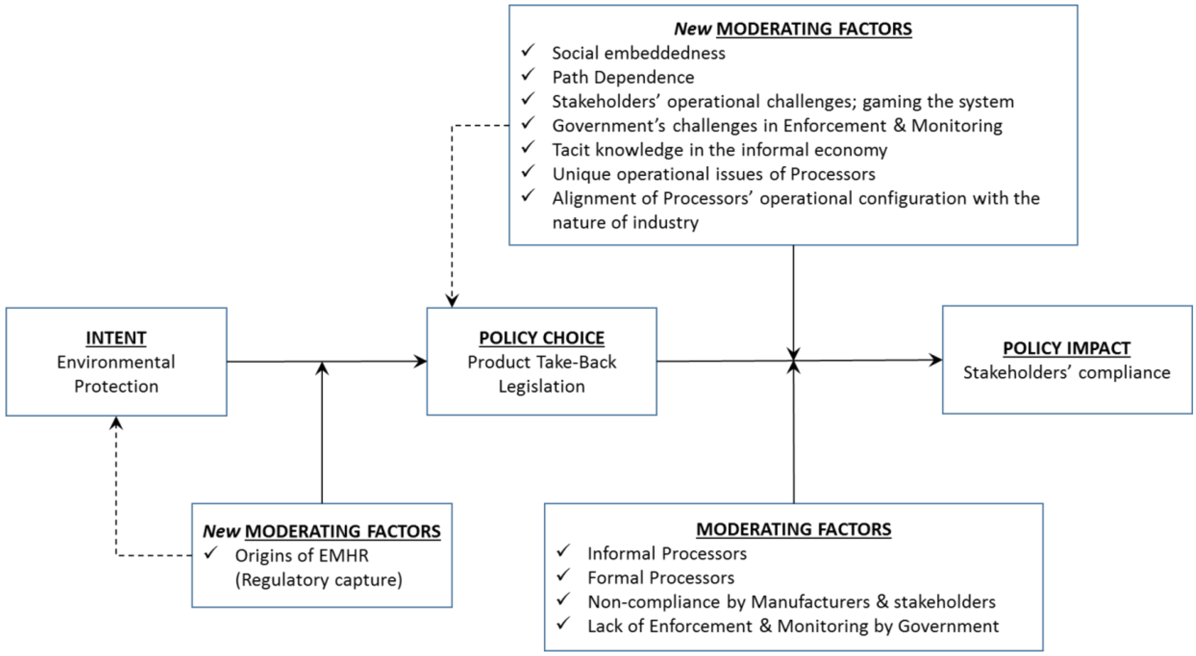


Figure 18: Knowledge of the phenomenon, after fieldwork



The dotted lines in Figure 18 theorize that these new moderating factors also suggest modification in the intent and policy choice. For example, the concept of regulatory capture may influence the intent i.e. environmental protection need not have been the sole objective of the policy choice (EMHR). The concept of operational alignment, path dependence, etc. suggests a re-look or modifications of the current policy choice (i.e. do we *really* need a Product Take-Back Legislation?). Product take-back legislations (adopted from developed markets with strong institutions and small informal economy) that relies on costly enforcement (due to command-and-control approach) and criminalizes the informal economy, may not be appropriate for emerging markets (like India) with weak institutions and large presence of informal economy in every economic activity. This is discussed in detail, in the section on implications for public policy.

Our contribution responds to the call made by OM scholars by studying country contexts and providing conceptual framework to better understand the interaction of OM and take-back legislation (Atasu & Wassenhove, 2012).

6.2 Implications for Public Policy

The 30 revised propositions and 10 emergent themes, in itself, has direct implications for EMHR. When we began this research, EMHR had been notified in 2011 (effective from 2012). An analysis of this policy, based on field evidence, is presented in Table 79.

Table 79: An analysis of EMHR 2011, based on field evidence

No.	Clause in EMHR 2011	Field evidence
1.	The rules shall not apply to micro and small enterprises as defined in the MSME Development Act, 2006	Majority of Formal Processors and Informal-turned-formal Processors fall under MSMEs, because their investments are less than Rs. 25 lakh. So, in theory, they need not comply with EMHR. However, this clause has removed in the 2016 supersession.
2.	The producer of electrical and electronic equipment shall be responsible for:	
	a) Collection of e-waste generated during the manufacture of electrical and electronic equipment and channelizing it for recycling or disposal.	a) E-waste generated during manufacturing is sold to Scrap Traders/Informal Processors. (*vide P8 in Chapter 5*)
	b) Collection of e-waste generated from the 'end of life' of their products in line with the principle of EPR and to ensure that such e-wastes are channelized to registered dismantler or recycler. Producer shall, as necessary, ensure collection and channelization by authorizing collection agencies.	b) Some Manufacturers have authorized Formal Processors (i.e. registered dismantlers) to collect and process e-waste, on their behalf. But, Manufacturers have not been able to ensure that all e-waste is channelized to Formal Processors. (*vide P18 in Chapter 5*)
	c) Setting up collection centers or take back systems either individually or collectively.	c) Some Manufacturers have set-up collection centers individually. This means collection bins are kept in service centers or retail stores. However, the amount of e-waste collected in these centers are very low. (*vide P18, Theme 6 in Chapter 5*)
	d) Financing and organizing a system to meet the costs involved in the environmentally sound management of e-waste generated from the 'end of life' of its own products and historical waste available on the date from which these rules come into force. The producer may choose to establish such a system either individually or by joining a collective scheme.	d) Such a system has not been established. However, Manufacturers sell the collected e-waste (from Retail and Bulk Consumers) to Formal Processors. Manufacturers face context-specific operational challenges to establish a take-back system in emerging markets (*vide Theme 6 in Chapter 5*).
	e) Providing contact details such as address, telephone numbers of authorized collection centers to consumers or bulk consumers.	e) This is being done by some Manufacturers i.e. symbolic compliance. (*vide P18, Theme 6 in Chapter 5*)
	f) Creating awareness through publications, advertisements, posters, or by any other means of communication and information booklets accompanying the equipment.	f) Short small-font information booklets accompany the equipment. But, consumers do not read it. There is lack of awareness i.e. no publications, no advertisements, no posters. (*vide P18, Theme 6 in Chapter 5*)
	g) Filing annual returns to the SPCB/ Pollution Control Committee on or before 30th day of June following the financial year to which that return relates.	g) This is being done by some manufacturers. (*vide P18, Theme 6 in Chapter 5*)
4.	a) Consumers or Bulk Consumers shall ensure that e-waste generated by them is channelized to	a) Some Consumers or Bulk Consumers comply with this. Many consumers continue

	authorized collection centers or registered dismantlers or recyclers or is returned to the pick-up or take-back services provided by the producers.	selling to scrap traders/Informal Processors. Moreover, many Formal Processors sell the collected e-waste to Informal Processors. (*vide Theme 6 in Chapter 5*).
	b) Bulk Consumers shall maintain records of e-waste generated by them and make such records available for scrutiny by the SPCB/Pollution Control Committee.	b) Records are maintained, but these records do not reflect the reality. Fudging of accounts does happen. (*vide P18, Theme 6 in Chapter 5*)
5.	Every dismantler shall:	
	a) Obtain authorization and registration from the SPCB in accordance with the stipulated procedure.	a) Only some dismantlers obtain authorization and registration. Informal Economy continue to persist.
	b) Ensure that the dismantling process do not have any adverse effect on the health and the environment	b) Many authorized dismantlers do not adhere to the safe dismantling process.
	c) Ensure that dismantled e-waste are segregated and sent to the registered recycling facilities for recovery of materials.	c) Dismantled e-waste are sent to informal (not authorized) commodity traders/recyclers.
	d) Ensure that non-recyclable/non-recoverable components are sent to authorized TSDFs.	d) Non-recyclables are sometimes sent to TSDFs. Mostly, it is disposed in the open.
	e) File returns to the SPCB/Pollution Control Committee, on or before 30th June following the financial year to which that return relates.	e) This is being done by many registered dismantlers. But, numbers do not reflect reality.
	f) Not process any e-waste for recovery or refining of materials, unless he is registered with SPCB/Pollution Control Committee as a recycler for refining and recovery of materials.	f) Many registered dismantlers sell boards, for metal recovery, to Informal Processors. Sometimes, these dismantlers themselves do metal recovery without any authorization from Government. (*All of the above are from P18, Theme 6 in Chapter 5; P5(b), P7(b) in Chapter 4)*
6.	Every recycler shall:	
	a) Obtain authorization and registration from the SPCB/Pollution Control Committee in accordance with the stipulated procedure.	a) Only some recyclers obtain authorization/registration. Informal Economy continue to persist.
	b) Make available all records to the SPCB/Pollution Control Committee for inspection.	b) Records are maintained, but these records do not reflect the reality. Fudging of accounts does happen.
	c) Ensure that residue generated thereof is disposed of in a hazardous waste TSDF	c) Residue is sometimes sent to TSDFs. In many cases, it is disposed in the open.
	d) File annual returns to the SPCB/Pollution Control Committee, on or before 30th June following the financial year to which that return relates.	d) This is being done by many registered dismantlers. But, numbers do not reflect reality. (*vide P18, Theme 6 in Chapter 5; P5(b), P7(b) in Chapter 4)*
7.	The SPCB/Pollution Control Committee may, if in its opinion, the holders of the authorization has failed to comply with any of the conditions of the authorization or with any provisions of the Act or these rules and after giving a reasonable opportunity of being heard and after recording reasons thereof in writing cancel or suspend the authorization issued under these rules for such period as it considers necessary in the public interest.	- Government faces systemic resource constraints to monitor and enforce. - Impossible for Government to verify if submitted records are accurate. - Political economy of enforcement and monitoring: nexus of politics, business, and government (*vide Theme 6 in Chapter 5*)

Except point 1, all other points of EMHR 2011 exist in the superseded legislation (i.e. EMHR 2016[46]). However, certain new points are added in EMHR 2016. Manufacturers (Parts & Components Manufacturers in our conceptual framework) and Producers have been distinguished and responsibilities are mandated to both. Refurbishers are also identified as separate stakeholders and mandated to get authorized and registered. Emphasis is given for skill development of informal e-waste processors and assisting them to set-up e-waste processing facility. There are also collection targets set for producers and a mandate to participate in Producer Responsibility Organization for joint e-waste collection. However, *the fundamental nature of EMHR remains the same* i.e. the approach based on product take-back and mandating stakeholders to follow rules. A copy of EMHR 2011 and 2016 is included in Appendix 6 and 7, respectively.

Ideally, scientific research to understand a social phenomenon progresses in the following steps (synthesized from Meredith et al. (1989) and Swamidass (1991)):

(1) qualitative case research (using small purposive sample) to identify concepts and their interrelationships

(2) econometric modelling (using large-scale random sample) to verify and determine the strength of these interrelationships among concepts

(3) understanding the trade-offs among these interrelated concepts through stylized analytical modelling and simulation

This dissertation research is at step (1). A more complete understanding of the phenomenon (i.e. formalization and RSC) is possible by following the other two steps. Only after completing these steps, concrete *suggestions* for modifying e-waste legislation (EMHR) can be proposed. However, at the risk of skipping the other two steps, we suggest a few concrete *suggestions* (directional in nature) for e-waste public policy. These are listed below:

[46] Many environmental legislations (including EMHR) was superseded (and not amended) in the year 2016. This is was because, the current legislations were found to be ineffective. So, rather than amending the legislation, new legislation (supersession) was enacted. This was revealed by a respondent, who works closely with the Government.

I. **Product Take-Back Legislation is not appropriate**

Product take-back legislations (adopted from developed markets with strong institutions and small informal economy) that relies on costly enforcement (due to command-and-control approach) and criminalizes the informal economy, may not be appropriate for emerging markets (like India) with weak institutions and large presence of informal economy in every economic activity. Rather than discussing about effective enforcement, monitoring, and compliance of product take-back legislations, we need to discuss alternate policies.

The rationale for saying this is explained as follows. The original intent of product take-back legislation (as initiated in the developed markets) was to *divert e-waste from landfills* by mandating manufactures to collect and process e-waste (Lindhqvist & Lidgren, 1990; Lindhqvist, 2000; Fishbein, 1998). This was expected to improve resource recovery, reduce negative externalities, and incentivize manufacturers to develop greener products. However, the Indian context is different, as revealed in Chapters 4 and 5. E-waste in India does not reach landfills due to the resource recovery by informal economy. Following quotes illustrate this evidence:

> *"In India, e-waste is coming back into the system...it is never like this in western countries...there, once it is a waste, it is a waste.", "due to this scavenging, material is coming back to the system...this has become a cycle in India. It is not practiced as it is done anywhere in the world. E-waste management model that exists in developed countries is different from that in India."*
>
> - Managing Director of Component Manufacturers' Association

> *"E-waste is one waste which is…almost everything gets recycled…except may be the low-value goods like the lamps. Today…I even now challenge you…you go to any of the dump sites in India or any of the dust-bins in India, you won't see e-waste lying there. Even if you want, you throw your e-waste into the dust-bin…within like 15-20 minutes it will be taken away by somebody because there is value in it."*
>
> – Consultant X

This field evidence also supports the view of OM scholars who have urged to re-think about the universality of product take-back legislations. For example, Atasu & Wassenhove (2012) said the following:

> "It is also clear that a one-size-fits-all best case solution would not apply in different parts of the world and to different business environments. In other words, a successful policy model and implementation in one country may not necessarily work in another; not only because welfare perspectives may differ but also because operational constraints vary significantly between countries."

While evaluating propositions and discussing emergent themes in Chapters 4 and 5, we have discussed in detail the unique operational characteristics (stakeholders' gaming the system, unique nature of the e-waste processing industry, etc.). Product take-back legislation for countries like India, do not incorporate such unique operational characteristics. This concurs with the recent conversation in OM literature that re-examines if Europe moved in the right direction by developing take-back legislation for e-waste (Mazahir et al., 2018).

II. Facilitate markets to function

This can be achieved through the following methods:

a) Set-up Recycling Parks

Recycling Park is a congregation of recycling firms co-located in a common land and operates using shared resources. These firms derive common inputs/resources (water, electricity, etc.) to run their recycling facilities. For example, a single power generating facility operated by the Recycling Park provides electricity to all the firms. The firms have to pay very low price for this electricity. The firms can also use a common effluent treatment plant operated by the Recycling Park. Rather than each firm investing in an effluent treatment plant, all waste from all firms would be channeled to a common/shared effluent treatment plant.

Findings from this study has led to an understanding of the strength of the Informal Processors (with low costs, highly flexible operations). This strength can be capitalized (or preserved) and the negative environmental externalities & occupational diseases can be reduced by setting up Recycling Parks with a common pollution abatement technology installed (ex: a common

effluent treatment plant for all Processors involved in metal recovery operations). Such Recycling Parks, in spirit, would be similar to Software Technology Parks of India (STPI) that was established to provide infrastructure, eco-system, and ease-of-doing business for firms in the software industry. Such Recycling Parks would also promote setting up facilities for commodities recycling like plastic, glass, metals, etc. Setting up Recycling Parks would help provide infrastructure (ex: land, facility) and eco-system (commodity recyclers would be in the same location) that would lower costs. Also, such Parks would also mean all Processors are under the ambit of Government i.e. they are formalized! This concept of Recycling Parks have come up in many stakeholders' meetings. Both Informal and Formal Processors had discussed regarding setting up Recycling Parks as a potential solution to their operational problems. For example, Informal Processor A said:

> *"If I invest everything in the land, then I will not have any money to do business. So, it will be good if we get a land from the Industrial Area Development Board…they were talking about some recycling park and all that. If we get land, then we are planning to build a 10,000 sq. ft. facility."*

b) Provide Industry Status

Providing Industry Status (i.e. Government accords an official status of industry) for the e-waste processing industry, can enable financial institutions to meet funding needs of Processors. E-waste Processors operating in such Recycling Parks can also be given permission to import e-waste for processing, because the facilities would be within the direct control of Government. By providing Industry Status, what we mean is this: include e-waste processing in Schedule 1 of the Industries Development Act, 1951. This would enable the following: borrow loans from financial institutions at low interest, tax benefits, and reduces cost of borrowing. To provide an intuitive appeal of this idea of Industry Status, take the case of Indian film industry. Film industry in India was given Industry Status in 2001. Until then, the business of film making was dominated by kinship networks and financing of films happened through private financiers who charged significantly high interest rates (this is because banks refused to fund film production). Industry Status enabled access to finance from large financial institutions at low interest rates, corporates and conglomerates to make high investments in film production, eventually moving away from informal kinship-based activity to an organized

corporate business[47]. It is this similar intention that made the CEO of Walmart India to appeal for Industry Status for India's unorganized retail sector[48]. Thus, a seemingly small inclusion in Schedule 1 (i.e. providing Industry Status) can have deeper ramifications for the e-waste processing industry.

c) Scale-up QUARTZ Project

Based on the functioning of a supply chain enabled by Quartz Project, we infer that market mechanism can be induced to reduce the negative effects of informal e-waste processing (vide Theme 5 in Chapter 5). Government could persuade Precious Metal Refiners (based in countries like Singapore, Germany, Korea, etc.) to source PCBs from India to meet their raw material requirements. This can be done by bringing Precious Metal Refiners, Informal and Formal Processors together and facilitate them to trade with each other (a scaled up version of Quartz Project). However, we would also like to caution regarding the sustainability of this supply chain. This kind of a supply chain would create *dependencies*. After a few years, Precious Metal Refiners would decrease their purchase price of PCBs. Informal Processors would have lost their skill (tacit knowledge) in metal recovery and they would be *dependent* on this Precious Metal Refiner (i.e. the refiner will dictate the terms and conditions). From a country perspective, India would be at a disadvantage. So, eventually this solution may not be sustainable. If Government could encourage setting up a Precious Metal Refining plant in India, this dependency problem would be mitigated (from a country perspective). This would also help Processors (Informal and Formal) to receive timely payments and incur lower costs. Currently, Processors in India incur very high costs to ship the container to the facility of Precious Metal Refiner and have to wait for 4-5 months to realize revenues (which is uncertain and dependent on international commodity markets). Another potential solution could also involve investing in research & development and encouraging commercialization of metal extraction technologies from lab to the marketplace. For example, take the case of Prof. Veena Sahajwalla's research to build portable small-scale smelters that can extract valuable metals and alloys from PCBs, without the use of any hazardous chemicals or emission of toxic fumes (Gough, 2016). Such small-scale smelters, if commercialized successfully, can be placed in India's informal e-waste processing hubs. This would enable Informal Processors to do metal

[47] This summary of Indian film industry is synthesized from Ganti (2012).
[48] http://www.indiaretailing.com/2017/09/19/retail/indian-retail-needs-industry-status-says-walmart-president-ceo-krish-iyer/ , Accessed on Dec 1, 2017.

recovery without creating negative externalities. And, all these would work without any kind of a Product Take-Back Legislation.

To better illustrate our point of view (i.e. facilitating markets to function), let us contrast the electronics recycling industry (reverse supply chain) with the electronics manufacturing industry (forward supply chain). Consider the National Policy on Electronics 2012 prepared by DeitY (Department of Electronics and Information Technology, Ministry of Communications & IT, Government of India). This policy has several incentives schemes are available for the electronics manufacturing industry[49]. For example, under the Modified Special Incentive Package Scheme (M-SIPS), 20% of the capital expenditure incurred in SEZs (Special Economic Zones) and 25% of capital expenditure incurred in non-SEZs is reimbursed. For non-SEZs, the scheme also provides for reimbursement of excise duty for capital equipment. In high capital investment projects like fabrication facilities, it also provides reimbursement of operational expenditures which includes central taxes, duties, etc. The incentives, if any, offered by the State Governments are over and above the M-SIPS provided by the Central Government. Another scheme is to promote Electronics Manufacturing Clusters (EMCs). Under this scheme, assistance is provided for setting up of both Greenfield clusters (a geographical area identified to develop basic infrastructure and common facilities for electronics system design & manufacturing firms), as well as Brownfield clusters (geographical area where a high number of electronics system design & manufacturing firms are already co-located). For setting up Greenfield clusters, Government of India provides assistance of 50% of the total budget costs subject to a ceiling of Rs. 50 crores for every 100 acres of land. For setting up of Brownfield clusters, the assistance is up to 75% of the project costs subject to a ceiling of Rs. 50 crores. Government has notified more than 51 Brownfield clusters and approved 2 Greenfield clusters (as of September 2014). In a similar vein, we suggest such facilitative initiatives (e.g., setting up recycling parks) for electronics recycling too.

Sections II answer our research question regarding incentives to encourage formalization of informal e-waste processors. The intent of our suggested incentives is to *facilitate* markets to function. If the Government plays such a facilitative role, stakeholders (including informal processors) would decide the optimal mechanisms by themselves. In making these suggestions,

[49] This is based on the public speech delivered by Mr. Bharat Arora (Scientist "B", DeitY, Government of India) at Bangalore during September 24, 2014.

we do not claim that EMHR is not appropriate in itself. There are other useful clauses in EMHR, like restricting the amount of hazardous substances while manufacturing electrical & electronic products. Such clauses should continue to exist in EMHR. Modification is needed only regarding the product take-back clauses.

In essence, the implications of our research for e-waste public policy can be summarized in a single sentence: *Rather investing efforts in drafting and implementing Product Take-Back Legislation, it is worthwhile to invest the same efforts to facilitate markets to function*. Governmental intervention is needed only in the form of providing a facilitative role like setting up Recycling Parks, providing Industry Status. But, these may not be a long-term sustainable solution. The key challenge here is this: *what if, the economic value of commodities reduce to an extent that disassembly or metal recovery is not profitable*?[50] Then, Government may introduce a price at which commodities from Processors would be purchased by the Government, irrespective of the prices in the international markets. This is similar to the minimum support price offered to farmers, which is an important aspect of India's agricultural policy.

To re-iterate, the fundamental idea (or intent) behind our policy recommendations is to help Informal Processors preserve their operational alignment. This line of thinking has structural similarity with works done by scholars in other disciplines. For example, Damodaran (2006) studied forest policies pertaining to tribal communities in Kerala. Damodaran (2006) argued that the existing policies that forcefully 'displace' and 'mandate' best practices to tribal communities in the name of development (this is also *a kind of* formalization) are restrictive and there needs to be a shift in thinking. The following recommendation was provided: "…for a paradigm change in policy to occur, tribal communities need to be nurtured in forest settings" (Damodaran, 2006). Another example is that of Supervised Injection Sites (SIS)[51]. In summary, these are professionally managed organizations run by the Government to provide safe injection facility (to prevent HIV transmission) for illegal or recreational drug addicts/users (van Beek, 2004). Considering the cultural and moral dimensions, a phenomena of this nature is more complex (and contested) than e-waste. Rather than ignoring drug addicts or forcing

[50] This idea was suggested by Consultant X

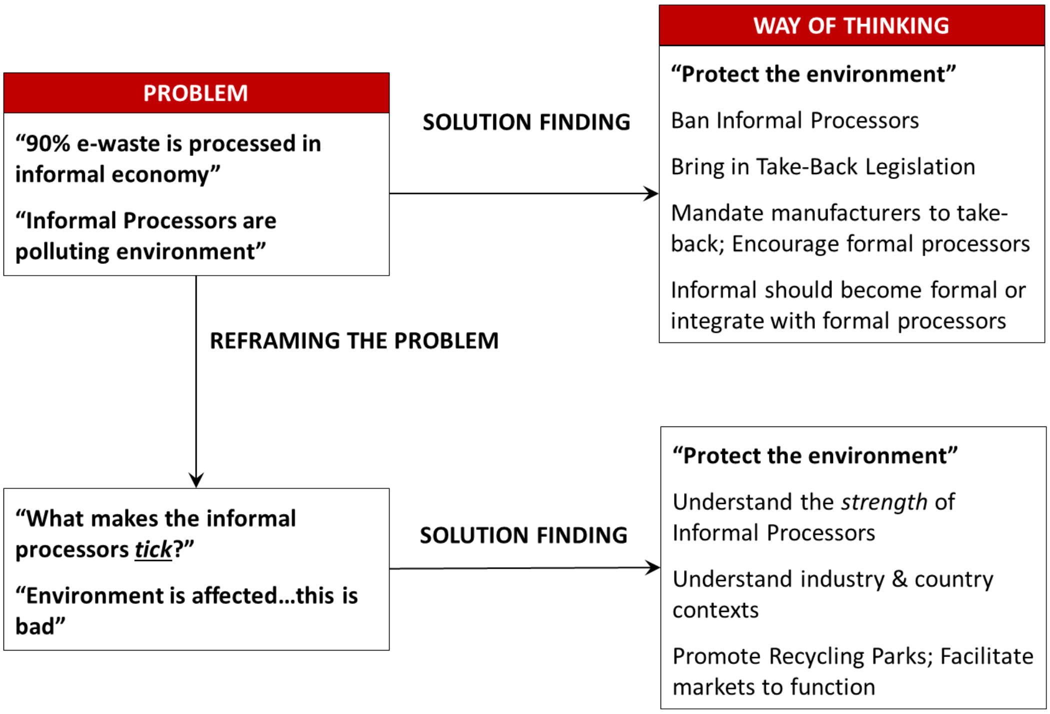
[51] I thank Prof. Rajiv Kozhikode for introducing this concept and interpreting it in the context of this dissertation. This idea was also communicated to a practitioner (from US EPA) while presenting this dissertation. The practitioner appreciated the connection to this idea and said it was relevant in the e-waste policy context.

them to stop using drugs, Government decided to provide them safe injection facilities. In management scholarship, this phenomena/policy practice is labeled as *high-stakes institutional translation* (Lawrence, 2017). This policy practice began in Europe and has spread to other parts of the world (developed economies). In a similar spirit, we offer an alternate way (through our policy recommendations) of viewing the e-waste phenomena. This is because scholars and policy makers have viewed e-waste phenomena in one way dominantly and have not got intended results (as revealed through this dissertation).

As discussed earlier in this chapter, this dissertation research is at step 1 i.e. exploratory qualitative case research. A more complete understanding of the phenomenon (i.e. formalization and RSC) is possible by following the other two steps. Only after completing these steps, concrete suggestions for modifying e-waste legislation (EMHR) can be proposed. The policy recommendations are at a high-level, giving a sense of direction. These recommendations are only suggestive or indicative in nature. In this dissertation, we do not discuss the conditions under which our policy recommendations would work. For conclusive policy recommendations, more field research using other methodologies needs to be executed. It is also to be noted that there are complimentary perspectives to address the e-waste problem. For example, scholarly conversation around setting up centralized versus decentralized recycling parks can be a separate research question in itself. Another perspective is to look at this phenomena using a longitudinal lens. Over a period of time the policy would evolve and stakeholders would gradually begin complying i.e. the policy would be able to *break* the path dependence nature of this industry. Our policy recommendations would be useful to initiate a meaningful scholarly conversation that traverses the trajectory of these complimentary perspectives.

By outlining these implications for e-waste policy, we are not claiming that our suggestions are frictionless. Adopting such market-based approaches comes with its own set of challenges. For example, Karnataka Government has proposed to set-up a 2,000 acre recycling park that is 120 km away from Bangalore city (Kumar, 2016). This is a centralized set-up and does not include the Informal Processors. The scholarly discussion can then move towards how to set-up decentralized recycling parks by including Informal Processors. Thus, our focus is to reframe the e-waste problem to a different dimension so that efforts can be channeled in appropriate ways. This point of view is illustrated in Figure 19.

Figure 19: Reframing the e-waste problem[52]



Though our study was from the point of view of a policy maker, there are implications for Formal Processors. Our interviews with numerous Formal Processors reveal that they face challenges to ensure steady supply of good quantity e-waste. This inability also erodes their profit margins and their facilities are under-utilized. Formal Processors would need to focus on replicating the "best operational practices" of Informal Processors. These best operational practices do not mean using unsafe processing operations and damaging employees' health and environment. Rather, these operational practices imply running a *low-cost and flexible processing facility*. Making very high investments (say, Rs. 1 crore) in an e-waste processing facility with automated, specialized machinery is not how a Formal Processor must organize itself.

In this chapter, we integrated findings from Chapters 4 and 5 and discussed overall findings and implications for e-waste public policy. The next chapter discusses validity of our findings, limitations of our study, and avenues for future research.

[52] This style of presentation is adopted from Wedell-Wedellsborg (2017)

Chapter 7: Conclusion

In this chapter, we explain the internal and external validity aspects of this study. Subsequently, limitations of the study and avenues for future research are pointed out.

7.1 Internal and External Validity

Internal Validity

In Chapter 3B, we have described the process followed for evaluating propositions and emergent themes. This process which involved carefully separating various evidence from primary sources (interview transcripts, memos, direct observation & informal conversation) and secondary sources (in-vivo search and systematic search using news databases), sentence-by-sentence coding and tagging with numbers have enabled the data analysis to be replicable and transparent. Wherever possible, rival explanations pertaining to the propositions or emergent themes are discussed. This replicable, transparent process is a key component of qualitative case research that enables to strengthen the internal validity (Ketokivi & Choi, 2014).

External Validity

External validity implies the need for a research study's findings to be generalized over a domain (or broader theory). In large-sample based econometric models, this validity is achieved through statistical generalization. In small-sample based qualitative case research, this validity is achieved through analytic generalization. Yin (2009) writes regarding this notion of external validity or generalizability:

"Critics typically state that single cases offer a poor basis for generalizing. However, such critics are implicitly contrasting the situation to a survey research, where a 'sample' (if selected correctly) readily generalizes to a larger universe. *This analogy to samples and universe is incorrect when dealing with case studies*. This is because survey research relies on *statistical* generalization, whereas case studies (as with experiments) rely on *analytical* generalization. In analytical generalization, the investigator is striving to generalize a particular set of findings to some broader theory."

This study can be subjected to analytical generalization by conducting new case studies (i.e. more informal-turned-formal firms, more stakeholders in the supply chain, etc.) and improving the conceptual framework. A collectively exhaustive set of such case studies are impossible in a single research endeavour (Yin, 2009). However, we establish a domain (a broader theory/conceptual framework) into which particular set of findings from this research can be generalized.

Rather than focussing on drawing conclusions from a sample to the population i.e. statistical generalization, we try to draw conclusions from the context or setting of this qualitative study to other contexts/settings with comparable characteristics[53]. What we have found regarding the Informal-turned-formal processors in Bangalore's scrap market neighborhood or a Formal Processor in Pune's industrial outskirts or a Scrap Merchant in Bamboo Bazaar (in Bangalore) can also be found under similar circumstances anywhere in India irrespective of the time period. Having described our study in specific detail (through propositions and emergent themes), and explaining the broader theory / domain where this is applicable (i.e. reverse supply chain dominated by processors in the informal economy and Formal Processors attempting to enter this reverse supply chain), we next show what other industry contexts are likely to belong to this broader theory / domain.

In Chapter 6, we had logically argued why Informal Processors have the best possible business model i.e. alignment of their operational configuration with the nature of e-waste processing industry. This finding is consistent with the observations made in the reverse supply chains of other industry contexts. For example, take the case of PET bottle recycling industry. When Bisleri (a large Indian beverages company that holds 40% market share of packaged drinking water industry in India) ventured into the business of collecting & processing discarded PET bottles, and selling the processed output (i.e. polyester fibre) to recycling firms that make caps, shirts, baskets, bags, etc., they partnered with the informal economy which included rag pickers and scrap dealers (Vijayraghavan, 2010; Patel, 2015). Bisleri had set a certain minimum price to collect the discarded PET bottles and they purchased it from the informal economy (Vijayraghavan, 2010). Bisleri's Managing Director said regarding this initiative (Patel, 2015):

[53] This reasoning style is suggested in Becker (2007)

“This initiative took a lot of groundwork; ragpickers don't collect PET bottles as it doesn't fetch them money in return. We wanted to change this and hence networked with them and asked them to collect PET bottles, for which we compensated them.”

The following was reported regarding the experience of Bisleri to get into the network of the informal economy of rag pickers (Vijayraghavan, 2010):

“Stitching together a partnership with rag pickers wasn't easy. They are a close-knit community that's driven by trust and fear. Each rag picker has his turf marked out and no one ventures outside it without the leader's permission. And if one of the members violates the unwritten code, the whole fraternity disowns him or her.”

In another case, Coca-Cola India partnered with the informal economy to collect discarded PET bottles (The Economic Times, 2011). For a discerning researcher, these two firms are *not doing* corporate social responsibility or social empowerment, by partnering with the informal economy. They are doing this to capitalize on the strength of the informal economy. This is because reverse supply chains of PET bottles dominated by the informal economy are path dependent, socially embedded, and operational configuration aligned with the unique nature of this industry. *Though these large firms like Bisleri and Coca-Cola can establish and efficiently run large-scale network of dealers and distributors in the forward supply chain throughout India, they are less likely (or impossible) to replicate this success in the reverse supply chain*. There is no other option for them other than partnering with the informal economy through some kind of supply chain contracts. Even large pure-play recylers like Arora Fibres and this entire industry which consists of about 20 recyclers who process discarded PET bottles into polyester fibre, depends on the informal economy for their raw material (Nayak, 2013). In another case, EnCashea (on online platform, for collecting & selling waste/scrap, that obtained seed funding from the co-founders of FreeCharge) had started with following objective[54]: “We, at EnCashea, are changing the way scrap (high value recyclable waste) get disposed in the country. We are using technology to solve the reverse supply chain issue in the USD 17 billion scrap industry.” However, they had to shut down their operations in two years “due to an unsustainable business model that runs on thin margins, but necessitates incremental working

[54] Source: LinkedIn Profile (https://www.linkedin.com/in/priyankjain87/) of the Co-founder of EnCahea, accessed on June 20, 2017.

capital" (Paul, 2017). Recently, EnCashea was bought by Hasiru Dala which is a non-profit organization that improved lives of waste pickers and scrap traders in the informal economy (Paul, 2017).

Now, we shift our focus from the RSC of PET bottles and scrap to RSC of used lead-acid batteries (LABs) and end-of-life vehicles (ELVs). Interviews with the stakeholders in used LAB processing industry reveal that, RSC of LABs have the similar structure of e-waste RSC (Krishnan et al., 2016). Though specific details would differ (ex: LABs are more homogenous when compared to e-waste), a structural similarity exists between the RSC of used LABs and e-waste (Krishnan et al., 2016). Structural similarity includes the following:

- ✓ Large presence of informal economy in used LAB processing leading to negative environmental externalities and occupational diseases.
- ✓ Batteries Management and Handling Rules (BMHR) enacted in 2001 and amended in 2010. BMHR is a product take-back legislation and has the similar structure of EMHR. Interestingly, both these legislations (i.e. BHMR and EMHR) were drafted by the same policy maker.
- ✓ Formal Processors of used LABs face competition from Informal Processors; key challenge faced by Formal Processors is to procure used LABs in sufficient quantity and to improve capacity utilization.
- ✓ Financial transactions in this industry (i.e. pricing) is dependent on virgin lead prices traded at LME.
- ✓ BHMR did not have the desired impact on modifying the RSC; Informal Processors continue to persist; Many stakeholders (ex: Bulk Consumers, Manufacturers) do not comply with BHMR.

For example, important stakeholders in the LAB industry said the following regarding LAB recycling and BMHR:

"*It is good that Government came up with the legislation. But, no legislations work in India. For each and every legislation people find loop holes. In India, there is a collection mechanism in place. But, used batteries do not come back to registered recyclers. Unregistered recyclers take batteries from consumers as they can give a higher price than registered recyclers.*"

– Director of a medium-sized LAB manufacturer and recycler, based in Bangalore[55].

"*Used batteries are not going to authorized recyclers. Unauthorized, informal recyclers are buying the used batteries. Though there is Battery Rules, there are loopholes […] Government should also keep one thing in mind. When they track and close down small informal recycling units, the problem is not getting solved. These people move to some other location and start new informal recycling units. These people are poor and are doing this for a living.*"
– A veteran of the LAB industry in India who owns a large-scale LAB manufacturing-cum-recycling facility at Hyderabad[56].

There is also a structural similarity with respect to the RSC of ELVs. This includes a large presence of informal economy in processing ELVs, their processing leading to negative externalities and occupational diseases, and Formal Processors & NGOs urging the Government to enact a product take-back legislation for ELVs (Chaitanya, 2016). Based on our study, we predict a similar pattern in the reverse supply chain (Figure 17), if ELV legislation is mandated.

There is also evidence from other countries (with a dominant presence of informal economy) in other industry contexts (including forward supply chains) where MNCs or Formal Firms have exited the market or partnered with the informal economy, because it was impossible to compete with them (Capps, 2011; Neuwirth, 2011). But, discussing these evidence are outside the scope of this dissertation.

7.2 Limitations of this study and avenues for future research

One obvious limitation of any qualitative case study is the small sample size. Fieldwork for this study spanned 2 years, interviewing 49 stakeholders in the e-waste RSC, and participating in industry conferences. This was the best possible sample size, given the limited time and funding[57]. With the availability of more resources, this sample size can be increased. For

55 Personal communication
56 Personal communication
57 There was no separate funding available for conducting fieldwork. This fieldwork was done with a personal investment of over Rs. 1 Lakh. Towards the end of the fieldwork, a mini grant ($1,000) was received as part of the Obama-Singh Fellowship. However, the sanctioned monetary grant is yet to be received.

example, one could interview informal-turned-formal processors who were recently formalized in Delhi and Kolkata, to understand their formalization process. More Informal Processors can be interviewed in Delhi. Though it might to be difficult to reach such stakeholders, more resources (funding and time) can be utilized to spend extended periods of time in such places to get rapport with appropriate stakeholders.

Apart from the limited sample size, another limitation of this study is *end-to-end tracing* of the RSC. Consider this supply chain where a particular Bulk Consumer sells e-waste to particular Formal Processor and this stakeholder in-turn sells to a Dealer in second-hand market. If a researcher is able to interview these particular stakeholders, it can be called as *end-to-end tracing* and doing this increases the internal validity of the study. In this study, we have tried all possible means to achieve this, using snowball sampling. For example, the Formal Processor CIT purchased e-waste from the Bulk Consumer MIB; Informal-turned-formal Processor Gamma gave hazardous waste to the Incinerator IMT; Retail Consumers 1 and 2 disposed e-waste to the collector BB; etc. But, it was not possible to trace the RSC end-to-end. Future research (using more funding and time) may *attempt* to trace a single chain consisting of Bulk Consumer => Formal Processor => Commodity Recycler or Trader => Manufacturer.

Another potential approach to increase the internal validity of this study, would be to closely study one Informal Processor through the entire process of formalization and after becoming formal. Such a longitudinal study, which is conducted as and when the events unfold, would reveal more detailed evidence (*micro evidence*) that can strengthen the internal validity.

Lack of numerical evidence (ex: by how much percentage did the profit decrease after becoming formal? How did the revenues change over a period of time for informal-turned-formal processors? What is exact capacity utilization percentage of Formal Processors?) could possibly cast a shadow on the findings of this study. Following Done et al. (2011) we have justified this lack of numerical evidence while studying such small-scale firms. Interestingly, our study also revealed scenarios where stakeholders game the system and fudge numbers i.e. Formal Processors do not report the exact quantity of e-waste received and commodities disassembled to the SPCBs. This finding is also a lesson for future research, which warrants developing some proxy scales to implicitly measure the key performance indicators like profits, revenues, etc. For example, rather than asking about profits to an informal-turned-formal processor, one can ask about which schools (English medium or otherwise) do their kids go to

before and after becoming formal; to measure the health impacts of e-waste processing, one can ask how frequently the employees wash their face / clean their nose, buy abdominal pain killers (i.e. medicines) or how many bananas they eat, etc. These are evident from non-economic outcomes discussed in Proposition 11 of Chapter 4. OM scholars would need to draw from the literature on conducting large sample socio-economic census, to identify such scales.

A number of avenues for future research are identified below:

(A) Extending knowledge on e-waste processing industry

Qualitative case research with more stakeholders (by following the same interview protocol) can be conducted. This would help strengthen the conceptual framework developed for understanding formalization and e-waste RSC. Methodologists who specialize in exploratory qualitative research label such set of sequential field studies as *concatenated exploration* that helps to strengthen the conceptual framework cumulatively (Stebbins, 2001).

A subset of propositions and emergent themes discussed in Chapters 4 and Chapter 5 can be made more precise to be tested on a large representative random sample or the population (ex: all the informal-turned-formal e-waste processors in India or all 3,000 scrap traders in Bangalore, etc.) through survey research methodology. This would help to test for the strength of association between the concepts identified in this study. For example, a rigorous test for path dependence can done for the e-waste processing clusters in Bangalore, Delhi. Such a test would be similar to the path dependence test done for knit-wear manufacturing cluster in Tirupur (for example, see Chari (2000)). This would also include testing for the degree of path dependence i.e. first-degree, second-degree, or third-degree (Liebowitz & Margolis, 2000).

A third dimension to extend this work is through analytical modelling & simulation studies. Incentive conflicts between few select stakeholders in the e-waste RSC can be studied (to understand trade-offs) using stylized analytical models. For example, having understood the existence of Quartz Project (vide Theme 5 in Chapter 5), the supply chain contracts could be designed that incentivizes Informal Processors to sell PCBs to Formal Processors / Precious Metal Refiners within the context of severe uncertainty of commodity markets fluctuations. System Dynamics can be used to model the e-waste RSC to capture complex interaction

between the stakeholders across the various stage of RSC. For example, the proposition of EMHR creating livelocks in the RSC (vide Proposition 18 in Chapter 5) could be tested by simulating the RSC using system dynamics modelling.

In Section 7.3, we show the potential to construct analytical models based on evidence obtained from this qualitative field study. In this section, we pick few "sub-chains" or "stakeholders' interactions" (based on select propositions and emergent themes) in the e-waste RSC to construct and analyze simple analytical models.

(B) Studying other reverse supply chains and crafting an overarching theory

As explained in the section on external validity, reverse supply chains of other industries like LABs, ELVs can be studied, using a similar qualitative case based methodology by testing the relevant propositions developed for e-waste RSC. Such studies of various industries offer rich potential to build an overarching theory of reverse supply chains in emerging markets like India and would contribute to the ongoing process of building a theory of product take-back legislation.

(C) Integrating knowledge from other disciplines

During the course of this research, there was a realization about the need for extending the boundaries of disciplines. For understanding such phenomenon like informal economy and reverse supply chains within a country context, future scholars would need to read the large body of sociology, anthropology, and economic history literature rooted in that particular country context. For example, OM scholars attempting to study the informal economy, reverse supply chains in India need to closely read the books and journal articles written by scholars like Tirthankar Roy, Barbara Harriss-White, Jan Breman, Mark Holmstrom, etc. who have spent years doing intense fieldwork on small-scale firms in India's informal economy and local markets. Their rich descriptions of phenomenon can be used to develop appropriate conceptual frameworks and research designs. For example, Harriss-White (2003), Holmstrom (1984) describe in detail the dynamics between formal economy and informal economy in various small-scale industries and the path dependency nature of the informal economy. To summarize

our point of view, in a catchy phrase: *The OM as we know it, is not enough*! This point of view is also consistent with the nature of OM discipline as defined by Dervitsiotis (1981)[58]:

> "It is the study of a field where knowledge from the social sciences (economics, psychology, sociology), engineering, and mathematics comes together to create and operate productive systems for the satisfaction of human needs in products and services."

Theory, in a particular stream of literature, is built by a community of scholars who are spread across the world (March, 2007). This doctoral dissertation serves to engage, in a small way, in the ongoing conversation/process of building an overarching theory of e-waste product take-back legislation by a large community of respected scholars.

So far, we explained the validity aspects, limitations, and aveneus for future research. In the next section, 7.3., we explain a future research avenue by developing analytical models based on selected propositions/themes.

7.3 Constructing Analytical Models

In this section, we show the potential to construct analytical models based on evidence obtained from this qualitative field study. As such, it is extremely difficult to construct an analytical model that incorporates all the 30 propositions and 10 emergent themes. Constructing such a model would be too complex because the real-world is indeed complex, as evident from our field study. Rather, in this section we pick few "sub-chains" or "stakeholders' interactions" (based on select propositions and emergent themes) in the e-waste RSC to construct and analyze simple analytical models. Future scholars, may take this as a first step towards building nuanced models. We select Theme 5 and Proposition 17 from Chapter 5 to construct analytical models. Typically, analytical modeling consists of the following three steps in the particular sequence:

(1) Description of the phenomenon
(2) Model construction: specifying directionality and functional forms of variables, capturing the key trade-offs, including relevant constraints.

[58] This is a forgotten (or lost in the chaos) classic text.

(3) Optimization & analysis

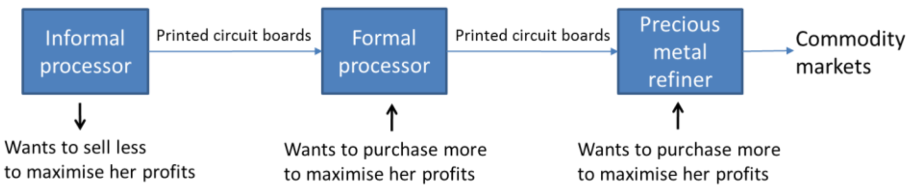
7.3.1 Interaction between Informal Processor and Formal Processor

(1) Description of the phenomenon

We had discussed the existence of QUARTZ project in Chapter 5. This was an emergent theme (Theme 5 in Chapter 5) from our field study. QUARTZ project, essentially, demonstrated the existence of a three-tiered decentralized reverse supply chain between Informal Processors (INF), Formal Processors (F), and Precious Metal Refiner (PMR). The stakeholders in the supply chain traded on printed circuit boards for metal recovery i.e. INF sold printed circuit boards to F who further sold it to PMR for metal recovery. Thus, hazardous metal recovery operation done by INF was "shifted" to safe environment-friendly operation at the facility of PMR. Thus, negative environmental externalities and occupational diseases, due to INF's metal recovery operation, was non-existent due to the market-mechanism of this supply chain.

To illustrate the possibility of model building, let us focus on the interaction between two players in this reverse supply chain: INF and F[59].

Figure 20: Reverse Supply Chain of QUARTZ Project



In the above figure, the flow of circuit boards are shown i.e. from INF to F to PMR. The flow of money is the reverse direction. F pays a fraction of the total money to INF immediately after receiving circuit boards, and pays the remaining fraction after a few months. This is because F receives payment from PMR only after a few months. In the above figure, one could quickly spot the incentive conflict between INF and F. Suppose, INF is able to collect 1 kg of printed

[59] Description of this interaction is taken from the NVivo Node: *Quartz Project*. Actual names of firms have not been used and associated references not cited, to protect the identity of respondents. However, the Node in NVivo contains all these details.

circuit board (of one product category, say, mobile phones) in day 1. INF cannot do metal recovery on that 1 kg, in a cost-efficient manner by using hydro metallurgy (i.e. using acids and other water-based solutions to leach metals from printed circuit boards). For doing metal recovery using hydro metallurgy, INF needs a minimum quantity of 5 kg. At the end of day 5, INF would have 5 kg printed circuit board. This is assuming that INF collects 1 kg of printed circuit board every day. At the end of day 5, INF faces two options. Option A is to do metal recovery using hydro metallurgy, and sell the recovered metal as a commodity to commodity dealers or manufacturers (for example, jewelry manufacturers). This will enable INF to make some amount of profits. Option B is to sell the 5 kg of printed circuit boards to F. For doing this, INF would have to incur some additional costs like re-sizing the shape of printed circuit boards into specific dimensions. F would give some amount of money for this 5 kg printed circuit boards, immediately to INF. The advantage for F is that, one container shipment can be filled quickly by sourcing printed circuit boards from various INFs. Otherwise, it would take longer time to fill one container shipment. Suppose, INF pursues Option B. For 5 kg printed circuit boards, F would estimate the revenues it can make (after 3-5 months) by selling to PMR. Based on this estimate, F gives some amount of money (a fraction of the estimate) immediately to INF. After this, F does a little metal recovery from the 5 kg sold by INF + quantity of printed circuit boards collected by F herself. F realizes a revenue by selling this metal in commodities market. Once the single container is filled, F decides to ship the container to PMR. It takes 3-5 months for F to realize revenues from PMR. This includes first sending a random sample to PMR for chemical analysis by a third party, time for shipment (via sea), time incurred by PMR to process the shipment sent by F, etc. It is to be noted that PMR uses pyro metallurgy process (i.e. using high temperature to melt circuit boards and extract metals) to extract metals from printed circuit boards. For this model, we do not focus on the interaction between F and PMR.

While focusing on the interaction between INF and F, one could observe that INF has an incentive to opt for Option A (INF does metal recovery by herself), if the returns from Option A is higher than that of Option B (INF sells circuit boards to F without doing metal recovery by herself). Offering a lower fraction is good for F, but not for INF. Offering a higher fraction is good for INF, but not for F. At equilibrium, there has to be an optimal fraction which is good for F and INF (i.e. both stakeholders are better-off). From the perspective of F, the key question is this: <u>*What is the optimal fraction for F such that INF would prefer Option B*</u>?

(2) Model construction

First, we develop profit functions for INF and F. While developing the profit functions, we define the variables and their notations.

Profit function of INF

$$\pi_{INF} = (Revenues) - (Costs)$$

$$\pi_{INF} = (Money\ paid\ by\ F\ immediately\ + Money\ paid\ by\ F\ after\ n\ time\ periods) \\ - (Costs\ of\ collecting\ and\ preparing\ printed\ circuit\ boards)$$

Money paid by F immediately: $\alpha\left(q_{in}(\alpha)\, p_f\right)$

1. α is the fraction paid by F immediately upon receiving the printed circuit boards, where $0 \leq \alpha \leq 1$.
2. $q_{in}(\alpha)$ is the quantity of printed circuit boards collected by INF. This is a function of the α offered by F. There are some interesting properties for this function $q_{in}(\alpha)$, which will be discussed later in this section.
3. p_f is the revenues than can be earned by F by extracting and selling metal from one printed circuit board. This is a function of the type of metal and the efficiency in its extraction/recovery process, quantity of metal that can be extracted, and price of metal in the commodity market.

Money paid by F after n time periods: $\frac{(1-\alpha)\left(q_{in}(\alpha)\, p_p\right)}{\delta_i^{n(\alpha)}}$

1. $(1 - \alpha)$ is the remaining fraction paid by F, after receiving money from the PMR.
2. p_p is the revenues that can be earned by PMR by extracting and selling various metals from one printed circuit board. This is a function of the types of metals and the efficiency in its extraction/recovery process, quantity of metals that can be extracted, and price of each metal in the commodity market. By the nature of its definition, $p_p > p_f$.
3. $q_{in}(\alpha)\, p_p$ is the revenues that can be earned from PMR (i.e. money paid by PMR to F) from the quantity of circuit boards collected by INF and sold to F.

4. $\frac{1}{\delta_i^{n(\alpha)}}$ is the discount factor, where the subscript i denotes that this factor captures the unique characteristics of INF. For example, for INF the money received today has *very high* value when compared to the money received tomorrow. It is to be noted that the time periods, represented by n, is a function of α. There are some interesting properties for this function $n(\alpha)$, which will be discussed later in this section.
4. In summary, $\frac{(1-\alpha)(\, q_{in}(\alpha)\, p_p)}{\delta_i^{n(\alpha)}}$ is the Net Present Value of the future cash flow that would be received after n time periods.

Costs of collecting and preparing: $c_i q_{in}(\alpha)$

1. c_i is the cost incurred by INF to collect and prepare (i.e. re-sizing into the specific dimensions required by F) one printed circuit board, so that it can be sold to F. It is non-zero and always positive i.e. $c_i > 0$. Also, $c_i < \; p_p, p_f$.

<u>Profit function of F</u>

$$\pi_F = (Revenues) - (Costs)$$

$$\begin{aligned}\pi_F = (&Money\ obtained\ by\ recovering\ \&\ selling\ metal\\ &+ Money\ obtained\ from\ PMR\ after\ n\ periods)\\ &- (Cost\ of\ \ collecting, processing, shipping + Money\ paid\ to\ INF)\end{aligned}$$

Money obtained by recovering & selling metal: $\left(q_{in}(\alpha) + \; q_f \right) p_f$

1. q_f is the quantity of printed circuit boards collected by F, by itself.
2. In summary, $\left(q_{in}(\alpha) + \; q_f \right) p_f$ is the revenues that are earned by F from the total quantity of circuit boards collected.

Money obtained from PMR: $\frac{\left(q_{in}(\alpha) + q_f \right) p_p}{\delta_f^{n(\alpha)}}$

1. $\left(q_{in}(\alpha) + \; q_f \right) p_p$ is the revenues that are earned by F by selling to PMR (i.e. the amount PMR pays to F) on the total quantity of printed circuit boards, after n periods.
2. $\frac{1}{\delta_f^{n(\alpha)}}$ is the discount factor, where the subscript f denotes that this factor captures the unique characteristics of F. For example, for F the money received today has *a high* value when

compared to the money received tomorrow. But, for F this value would be *less* when compared to the value of INF i.e. $\delta_i > \delta_f$. This is because INF needs money on a daily basis for survival and cannot wait for more time periods even if the returns are high. But, F can afford to wait for some time periods and do not need money for survival on a daily basis.

3. In summary, $\frac{(\ q_{in}(\alpha)+q_f)\ p_p}{\delta_f^{n(\alpha)}}$ is the Net Present Value of the future cash flow that would be received after n time periods.

Cost of collecting, processing, shipping: $c_f\ \left(\ q_{in}(\alpha) +\ q_f\right)$

1. c_f is the cost of collection and processing (i.e. preparing the collected circuit boards by re-sizing etc.) per circuit board. c_f also includes the shipping (or transportation cost) per circuit board.
2. It is to be noted that variables like c_i, c_f can be further decomposed into various other forms. For example, the shipping (or transportation) cost component of c_f is not linear with respect to the quantity of circuit boards shipped in the container. But, for the purpose of this model, we do not explicitly include such variations to keep the model simple (and parsimonious).

Money paid to INF: $\alpha\left(q_{in}(\alpha)p_f\right) + \frac{(1-\alpha)(\ q_{in}(\alpha)\ p_p)}{\delta_i^{n(\alpha)}}$

1. This expression is already explained in the profit function of INF. $\alpha\left(q_{in}(\alpha)p_f\right)$ is the money paid to INF immediately after receiving circuit boards, $\frac{(1-\alpha)(\ q_{in}(\alpha)\ p_p)}{\delta_i^{n(\alpha)}}$ is the net present value of the money that will be paid to INF after n time periods.

Functional forms of $q_{in}(\alpha)$ and $n(\alpha)$

1. Abstracting at a high-level, q_{in} is a linear function of α. However, there are more nuances here. There is some threshold α, say k, above which INF decides to sell circuit boards to F. Below this threshold, k, INF does not have any incentive to sell circuit boards to F i.e. it is profitable for INF to do the processing (metal recovery) by herself rather than selling the boards to F. Above this threshold, as α increases, INF would be incentivized to collect more

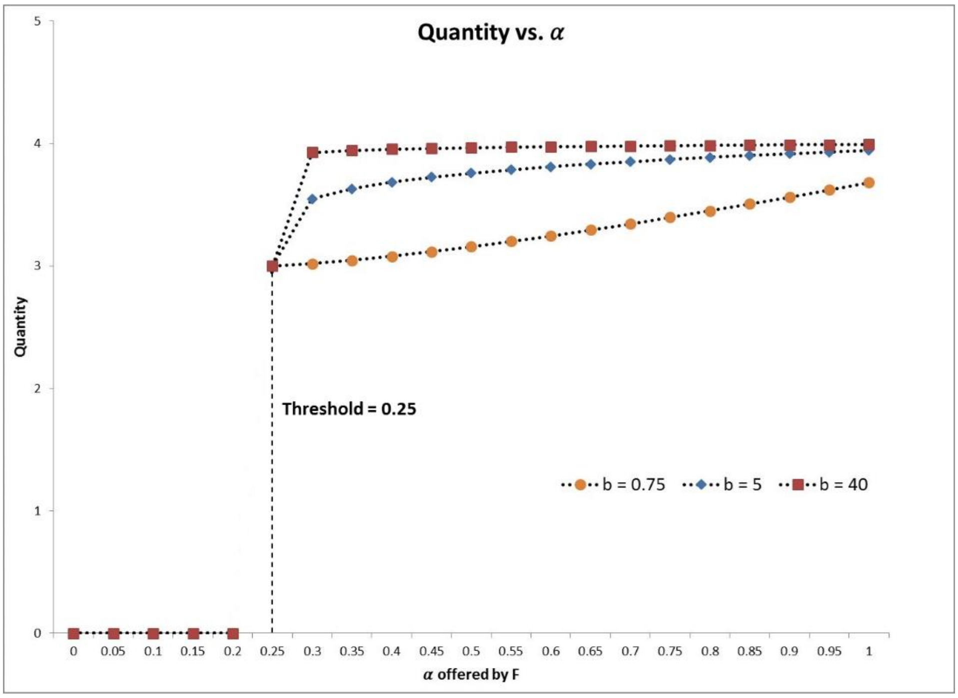
circuit boards and sell all of them to F. This behavior is captured in the following functional form:

$$q_{in}(\alpha) = q_0(\alpha - k)^{1/b} + q_i, \text{ when } \alpha \geq k$$
$$q_{in}(\alpha) = 0, \text{ when } \alpha < k$$

It is to be noted that the threshold k, is the *reference point* of INF i.e. $k = 0.25$ implies that INF *believes* it is not profitable to sell circuit boards to F unless F offers a fraction greater than or equal to 25%. This belief of INF need not be equal to the objective value of threshold i.e. INF cannot compute an objective value for k due to persisting information asymmetries (incorrect understanding of other parameter values like p_p, $n(\alpha)$, q_f, c_f, δ_f). This modeling construct (reference point) is drawn from the concept of *reference dependence* which is a fundamental principle in prospect theory from behavioral economics literature (Kahneman & Tversky, 1979).

This functional form is illustrated in the following Figure 21.

Figure 21: Functional form of $q_{in}(\alpha)$

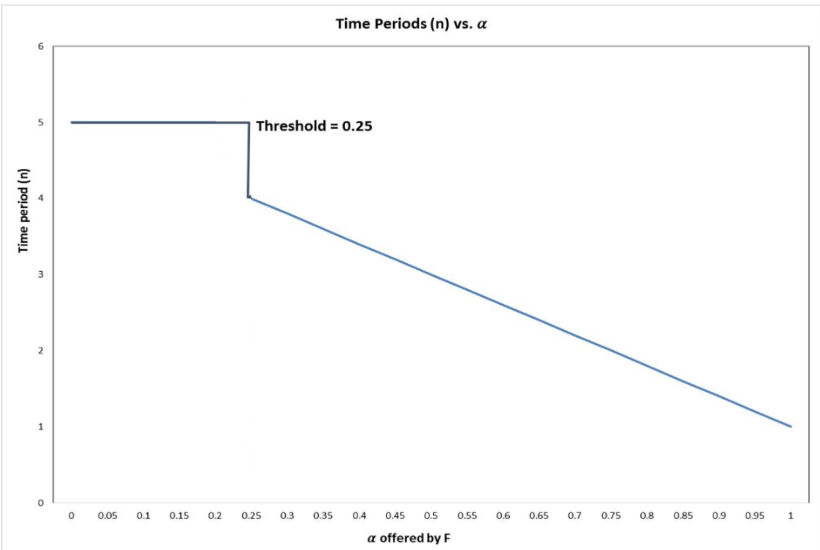


As α increases above the threshold, INF decides to collect more circuit boards and sell them to F. However, this relationship is not an increasing simple straight line. Rather, the increase in q for every unit increase in α is initially higher, and later decreases as α approaches 1.

This characteristic of the curve is a function of the nature of product (i.e. what type of metal can be extracted and how much does the market value it), captured by the parameter b. For example, mobile phones' circuit boards (F and PMR would even pay a premium to procure mobile phones' circuit boards from INF) would exhibit a different behavior when compared to televisions' circuit boards because the former has high quantities of precious metal like gold, silver, and platinum. The parameter b for mobile phones' circuit boards (with high quantity precious metals) would be very high when compared to the parameter value for televisions' circuit boards (with base metals like copper). q_0 denotes the total quantity of circuit boards available in the market, that can be collected by INF and sold to F. So, b is a product parameter and q_0 is a market parameter. Similar functional forms have been used in the literature on inventory-dependent demand (Baker & Urban, 1988).

2. $n(\alpha) = l - m\alpha$. This includes the time period needed to wait till the container gets filled with circuit boards, ship the container of circuit boards to PMR, and for PMR to recover metals and pay appropriate money to F. When $\alpha = 0$, $n(\alpha) = l$ i.e. there is always some minimum time periods required even when INF is not selling any circuit board to F. When $\alpha \geq k$, the quantity of circuit boards collected by INF (to be sold to F) increases, and this increases the frequency of shipments i.e. the container gets filled quickly and shipping is done. This translates to a reduction in n. The factor by which n reduces is captured by the market parameter m. This behavior is illustrated in the following Figure 22 (where $l = 5, m = 4$).

Figure 22: Functional form of $n(\alpha)$



The following table summarizes the notations and parameters used.

Table 80: Summary of notations and parameters

Notation / Parameter	Description
INF	Informal Processor
F	Formal Processor
PMR	Precious Metal Refiner
α	Immediate fraction offered by F to INF.
p_i	Revenues per circuit board, earned by INF, by recovering metal and selling metal in the market.
p_p	Revenues per circuit board, earned by F, by selling circuit boards to PMR.
p_f	Revenues per circuit board, earned by F, by recovering metal and selling metal in the market.
c_i	Cost per circuit board, incurred by INF.
c_f	Cost per circuit board, incurred by F.
q_{in}	Quantity of circuit boards collected by INF and sold to F (based on the α offered by F).
q_i	Base quantity of circuit boards collected by INF, irrespective of the α offered by F.
q_f	Quantity of circuit boards collected by F, out of her own efforts.
q_0	Total quantity of circuit boards available in the market.
δ_i	Discount factor of INF.
δ_f	Discount factor of F.
$n(\alpha)$	Time period to realize revenues from PMR: This includes the time period needed to wait till the container gets filled with circuit boards, ship the container of circuit boards to PMR, and for PMR to recover metals and pay appropriate money to F.
b	Product parameter. For example, mobile phones' circuit boards (with precious metals) have high b when compared to televisions' circuit boards (with base metals).
k	Threshold (reference point) perceived by INF.

(3) Optimization and analysis

We get the following objective function and constraints, by incorporating the above functional forms in the profit function of F. The overall objective is to Maximize the profits of F such that INF is able to get equal to or higher profits that INF can obtain without selling to F.

Objective function to be maximized w.r.t α:

$$-p_f\alpha\left(q_i+q_0(-k+\alpha)^{\frac{1}{b}}\right)-\ c_f\left(\ q_f+q_i+q_0(-k+\alpha)^{\frac{1}{b}}\right)+p_f\left(\ q_f+q_i+q_0(-k+\alpha)^{\frac{1}{b}}\right)$$
$$+\ p_p\left(\ q_f+q_i+q_0(-k+\alpha)^{\frac{1}{b}}\right)\delta_f{}^{-l+m\alpha}$$
$$-\ p_p(1-\alpha)\left(q_i+q_0(-k+\alpha)^{\frac{1}{b}}\right)\delta_i{}^{-l+m\alpha}$$

<u>Constraints:</u>

1. Profit of INF by selling to F should be greater than or equal to the Profit of INF without selling to F. Without an economic incentive vis-à-vis the existing situation, it is not possible for INF to sell circuit boards to to F. This constraint satisfies this condition.

   $Profit\ of\ INF\ without\ selling\ to\ F = q_ip_i - q_ic_i;$
   Where q_i = quantity of circuit boards collected by INF when it is not selling to F. Definitions for other variables remain the same, as discussed before. Profit of INF by selling to F, was discussed in sub-section on model construction. The equation below, depicts this constraint:

$$-\,c_i\left(q_i+q_0(-k+\alpha)^{\frac{1}{b}}\right)+p_f\alpha\left(q_i+q_0(-k+\alpha)^{\frac{1}{b}}\right)$$
$$+\ p_p(1-\alpha)\left(q_i+q_0(-k+\alpha)^{\frac{1}{b}}\right)\delta_i{}^{-l+m\alpha}>(-\,c_i+p_i)q_i$$

   This means the differential profit for INF (i.e. Profit of INF by selling to F - Profit of INF without selling to F) should be greater than zero.
2. $p_i > 0,\ p_p > 0, p_f > 0$: This denotes that all revenues are non-zero and non-negative.
3. $p_p > p_f$: Revenues per circuit board obtained for PMR is greater than what is obtained for F. This is because PMR can extract higher quantity of metal, more types of metal when compared to F. Using the same logic, $p_p > p_i$. However, this logic cannot be extended to claim $p_f > p_i$. This is because, for the same type of metal, INF would be able to extract higher quantity than F. But, there is no conclusive evidence from the field regarding this. Hence, we do not specify any relation between p_i, p_f.
4. $c_i > 0,\ c_f > 0$: This denotes that the variable costs are non-negative and non-zero. Based on field research, it is evident that costs for INF is significantly less than F i.e. $c_i <\ c_f$.
5. $c_i < p_i,\ c_f < p_f$: This is intuitive, ensuring that revenues are greater than costs.

6. $q_i > 0,\ q_f > 0, q_0 > 0$: This denotes that the quantity of circuit boards are non-negative and non-zero. Typically, q_0 (total quantity of circuit boards available in the market) is higher than what INF and F can collect individually i.e. $q_0 > q_i, q_f$.
7. $\delta_i > 1, \delta_f > 1, \delta_i > \delta_f$: This ensure that interest rate is positive, non-zero and INF has a higher discount factor than F.
8. $l > 0, m > 0, l > m$: This ensure that $n(\alpha)$ is non-negative, non-zero.
9. $b > 0, k > 0, k < 1, \alpha \geq 0, \alpha \leq 1, \alpha \geq k$: This satisfies functional form for $q_i(\alpha)$.

Differentiating the objective function w.r.t α and equating it to zero, we get the following:

$$
\begin{aligned}
-\frac{c_f q_0 (-k+\alpha)^{-1+\frac{1}{b}}}{b} + \frac{p_f q_0 (-k+\alpha)^{-1+\frac{1}{b}}}{b} - \frac{p_f q_0 \alpha (-k+\alpha)^{-1+\frac{1}{b}}}{b} \\
- p_f \left(q_i + q_0 (-k+\alpha)^{\frac{1}{b}} \right) + \frac{p_p q_0 (-k+\alpha)^{-1+\frac{1}{b}}\, {\delta_f}^{-l+m\alpha}}{b} \\
- \frac{p_p q_0 (1-\alpha)(-k+\alpha)^{-1+\frac{1}{b}}\, {\delta_i}^{-l+m\alpha}}{b} + \ p_p \left(q_i + q_0 (-k+\alpha)^{\frac{1}{b}} \right)\, {\delta_i}^{-l+m\alpha} \\
+ m\, p_p \left(\ q_f + q_i + q_0 (-k+\alpha)^{\frac{1}{b}} \right)\, {\delta_f}^{-l+m\alpha}\, ln[\delta_f] \\
- m\, p_p (1-\alpha) \left(q_i + q_0 (-k+\alpha)^{\frac{1}{b}} \right) {\delta_i}^{-l+m\alpha}\, ln[\delta_i] = 0
\end{aligned}
$$

It is evident from the above equation that it is difficult to solve for α. Hence, closed-form solution cannot be obtained. Thus, we need to do numerical analysis to understand how the profit function behaves w.r.t various parameters. We were not able to obtain "reliable" estimates of numerical data of the actuals values for parameters (like $p_i,\ p_p, p_f, \alpha, q_i$, ... etc.) from secondary sources. Hence, we resort to simple numerical analysis. Such an approach has also been taken by other OM scholars (for example, Atasu et al. (2009)).

Numerical Analysis

We use the following set of values for each parameter, for the analysis. This set of values satisfies all the constraints that were laid out earlier.

Table 81: Parameter values for numerical analysis

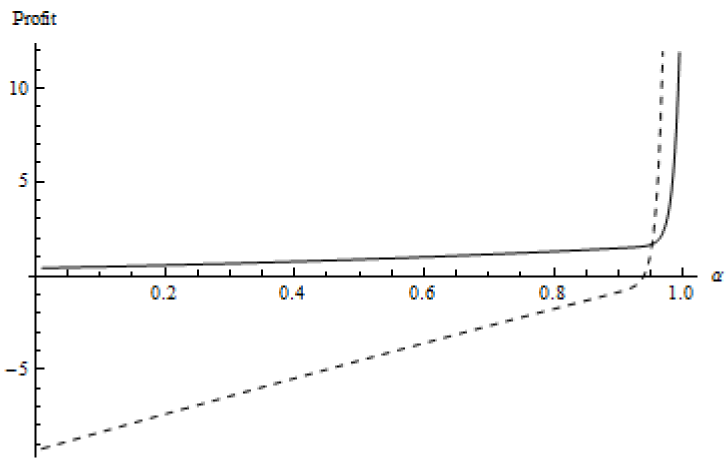
Parameter	Min	Max
α	0.01	1
p_i	10	20
p_p	21	30
p_f	10	20
c_i	1	5
c_f	6	9
q_i	1	50
q_f	1	50
q_0	100	100
δ_i	2	3
δ_f	1.1	1.9
l	5	10
m	1	4
b	0.01	5
k	0.01	0.99

The dashed line in the graphs (below) denotes the constraint of INF. This constraint line denotes the differential profits of INF (i.e. Profit of INF by selling to F - Profit of INF without selling to F). The solid black line denotes the profit curve of F.

<u>Case 1:</u> Base Case

At minimum values for all the parameters (i.e. the base case), following is the graph obtained.

Figure 23: Analysis of base case

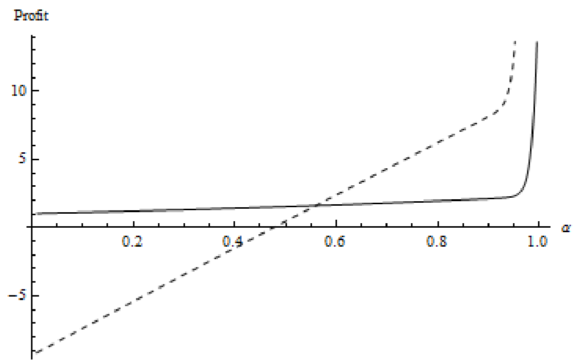
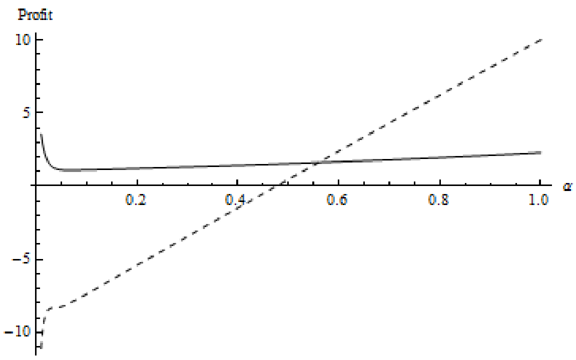


This denotes that when k (i.e. the threshold) is 1% (very low), F makes profits only when she pays a fraction equal to or more than 95% (very high) to INF, immediately after purchasing the circuit boards. This is because at low values of the product parameter b (i.e. ordinary base metals can be recovered from circuit boards), it is profitable for INF to do the metal recovery by herself rather than selling to F. Only if F offers a very high fraction of 95% or more, INF will find it profitable to sell to F.

Case 2: Metal recovery by Formal Processor when p_f is high

At maximum value of p_f, the behavior of graph is interesting by varying the threshold k (with respect to the base case).

Figure 24: Metal recovery by Formal Processor when p_f is high

When k = minimum	**When k = maximum**
	

When p_f is very high (i.e. maximum possible revenues realized by F), at any value of k (i.e. the threshold perceived by INF), F realizes a profit when α is equal to 60% or more. This means that, when revenues are improved, the Formal Processor would *always* make profit, if she offers to pay 60% or more immediately to INF. This is irrespective of the threshold values perceived by INF. Thus, in order to make profits, F should do the following:

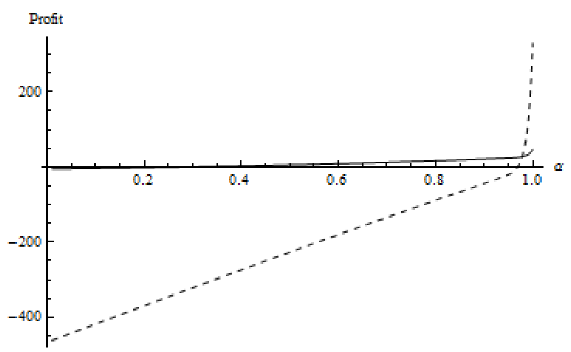
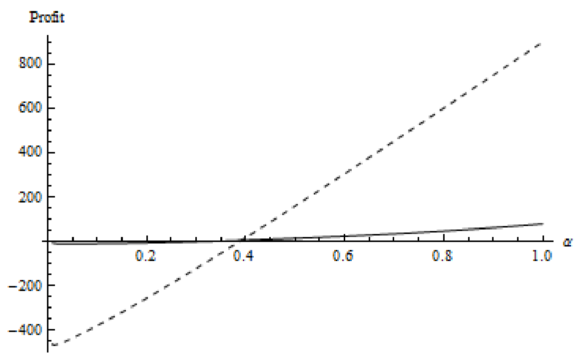
(1) Improve revenues (i.e. p_f)

(2) Increase the immediate fraction paid to INF (i.e. α)

Case 3: Immediate fraction offered by Formal Processor when b is low

At minimum values for all the parameters (i.e. with respect to the base case), when q_{in} increases, F realizes profits only when α is greater than 95%. This is because INF will always find it profitable to do all the metal recovery by herself rather than selling to F when the product parameter b is low. This is intuitive and consistent with our explanation for the base case. But, when the product parameter b increases (i.e. high quantity of precious metals can be recovered from the circuit boards), INF does not find it profitable to do all the metal recovery by herself. When F offers a lower α (greater than 40% in this case), INF will find it profitable to sell to F. Thus, F realizes profits by offering lower immediate fractions to INF when it purchases circuit boards containing high quantity precious metals. This is illustrated in the figures below.

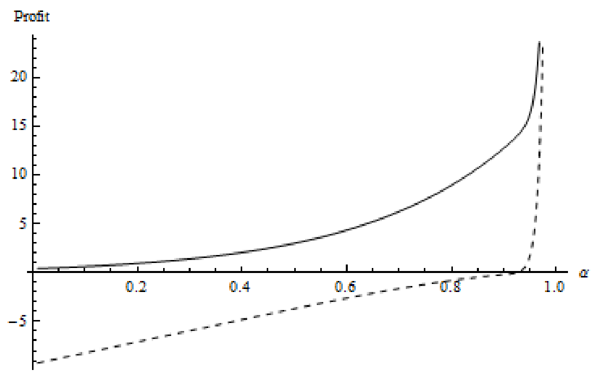
Figure 25: α offered by Formal Processor when b is low

<table>
<tr><th>When q_{in} is high and b is low</th><th>When q_{in} is high and b is high</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

Case 4: Profits made by the Formal Processor when $n(\alpha)$ is low

At minimum values for all the parameters (i.e. with respect to the base case), when $n(\alpha)$ reduces[60] (i.e. lower time period for F to realize revenues), the profits realized by F increases. This is because frequency of shipments increase and F receives money from PMR sooner than later. But, due to low value of product parameter b, INF always finds it profitable not to sell circuit boards to F. However, with the increase in product parameter value, F realizes higher profits even with low immediate fractions (25% or more) offered to INF. This is because INF finds it profitable to sell circuit boards to F at high product parameter value. This is illustrated in the following figures.

Figure 26: Profits made by the Formal Processor when $n(\alpha)$ is low

<table>
<tr><th>When time period is low and b is low</th><th>When time period is low and b is high</th></tr>
<tr><td>


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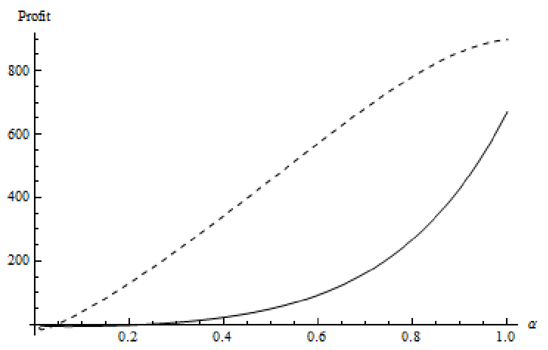


</td></tr>
</table>

Significant observations based on these numerical analyses are summarized below:

- In order to make profits, F should improve revenues (i.e. p_f), increase the immediate fraction paid to INF (i.e. α).
- F realizes profits by offering lower immediate fractions to INF, when it purchases circuit boards containing high quantity precious metals (i.e. high product parameter value).

Thus, by doing simple numerical analysis using the four cases, we show that this phenomenon can be modelled analytically and useful intuitive insights can be drawn. This model can be

[60] $n(\alpha)$ is reduced by increasing the value of parameter m .

further extended by collecting real data from firms (F, INF, PMR in the Quartz project) and modifying functional forms based on the data.

7.3.2 Interaction between Manufacturer and Processor

It was discussed in Proposition 17 (Chapter 5) that e-waste RSC exhibited the characteristics of closed-loop. By closed-loop, what we mean is this chain: Manufacturer produces printed circuit boards that are assembled into e-products (say, mobile phones) => consumers purchase and discard mobile phones after use => the printed circuit boards are disassembled from such phones and collected by the precious metal refiner => precious metal refiner recovers metals from printed circuit boards and sells it to the Manufacturer of printed circuit boards which then gets assembled in new mobile phones. This phenomenon could be abstracted to a higher-level to understand the interaction between Manufacturer and Recycler (i.e. precious metal refiner who recovers metals). This higher-level abstraction involves extracting metals from printed circuit boards or extracting lithium, lead from other components like batteries which are used to run electronic devices.

As described earlier in this chapter, analytical modeling of this part of the RSC would also consist of the following three steps in the particular sequence:

(1) Description of the phenomenon
(2) Model construction: specifying directionality and functional forms of variables, capturing the key trade-offs, including relevant constraints
(3) Optimization & analysis

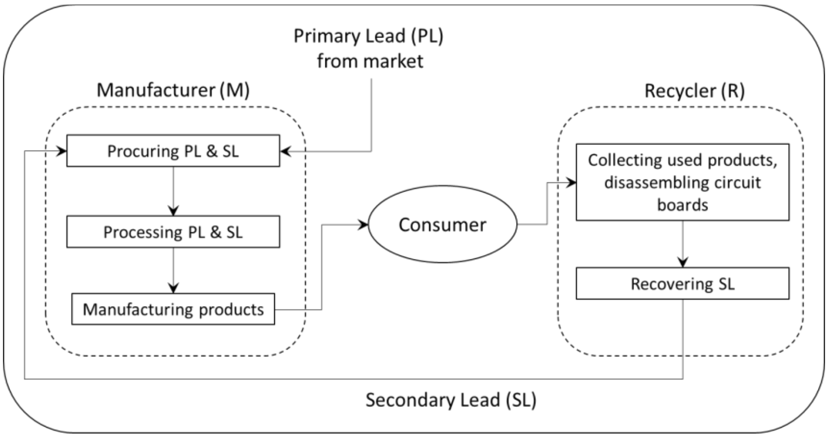
(1) Description of the phenomenon

Consider one manufacturer (denoted by M) that produces a specific product category (say, circuit boards for mobile phones) and one metal refiner (denoted by R). M procures a specific metal, say, primary lead[61] (denoted by PL) mined from ores from the market and secondary lead (secondary lead is the lead recovered from used products and denoted by SL) from R, to

[61] Lead is only one example of a metal that can be recovered from printed circuit boards. Other metals are copper, platinum, gold, silver, palladium, etc. In this entire model, terms like primary lead, secondary lead can also be replaced with terms like primary copper, secondary copper or primary lithium, secondary lithium (in a battery context), etc.

manufacture new products. The price of PL is higher than SL. The price of PL is determined by the market (i.e. based on demand and supply dynamics of PL and SL). M can mix PL and SL in appropriate proportion to make new product. Different costs are incurred in processing PL and SL. The processing cost of SL is higher than the processing cost of PL. This is because SL may have to be refined/processed further to match to the level of PL. Thus, M manufactures new product by procuring and processing PL, SL. Consumers use the product and discard it. R collects the used product and recovers lead (i.e. SL) from it. R incurs collection and recovery costs. SL, recovered by R, is sold to M for making new products. The price at which R sells SL to M is less than market price of PL. A graphical illustration of this description is shown in Figure 27.

Figure 27: Manufacturer and the metal Recycler



M has to decide on improving environmental quality to the product. For the purpose of this model, by environmental quality we mean design for recovery (DfR). For example, avoiding mixes of metals that are hard to separate (this reduces recovery costs for R); reformulating the composition of dangerous substances (like cadmium, phosphorus, etc.) so that it is less toxic when disposed (this reduces recovery costs for R); designing the product so that more lead (or any other metal) can be recovered. If M improves environmental quality, it is easy (less costly) for R to recover lead from used products and more lead can be recovered by R. This enables R to sell SL at a lesser price than before (i.e. without improvements in environmental quality) to M. Following is the rationale for R to reduce the price. R cannot sell SL at a price that is equal to or higher than the market price of PL. This is because M will always buy PL from the market if R prices SL equal to or above the market price of PL. When M improves environmental quality, output of R increases and marginal cost of R reduces. Assuming that R faces a linear

downward sloping demand curve (i.e. as price of SL increases, M will reduce the quantity of SL purchased), it has to reduce prices to sell more output. Hence, R has to reduce the price of SL so that M can procure more SL. M purchases more SL from R and uses it to make new product. Consequently, M reduces procurement of PL from the market and also has to incur extra processing costs for SL.

The opposing forces that M has to balance when it improves environmental quality, are as follows: There will be investment costs, higher manufacturing costs, lower procurement of PL from the market, lower processing costs for PL, lower price paid to per unit SL, higher procurement quantity of SL, and higher processing costs for higher quantity of SL procured. The opposing forces that R has to balance when M improves environmental quality, are as follows: There will be reduction in recovery costs, increase in quantity of SL recovered, reduction in selling price of SL to M, and increase in quantity of SL sold to M.

(2) Model construction

We can model the profit functions of M and R separately and try to get the optimal environmental quality. But, we model the average cost function of only M and include the opposing forces faced by R by manipulating the cost function of M. Thus, we are able to model a single cost function for M that includes opposing forces faced by M and R.

$$\begin{aligned} &Total\ costs\ per\ unit\ for\ M \\ &\qquad = investment\ costs + manufacturing\ costs + procurement\ costs \\ &\qquad + processing\ costs \end{aligned}$$

Let us explain each of these costs components. Assume s to be the level of environmental quality that M can provide, $0 \leq s \leq 1$.

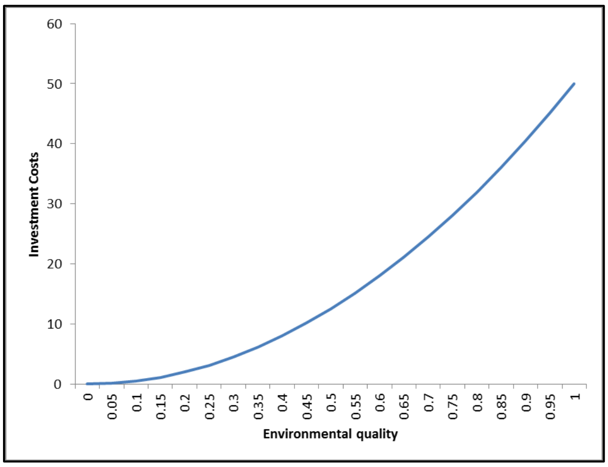
Investment costs (I_C)

$$I_C = Is^2$$

We have assumed a quadratic function. If M does not provide any DfR, there is no investment required to provide the DfR. If decides to provide DfR (some level of s), it will have to incur investment costs Is^2 irrespective of the number of units manufactured. I_C is set-up costs for

providing a DfR level s. I can only take non-zero positive values i.e. $I > 0$. Otherwise, investment costs will be negative or zero which is not possible in reality. There will always be some positive investment costs to provide a certain level of environmental quality. The directionality and functional form is illustrated in Figure 28 below.

Figure 28: Directionality and functional form for investment costs



There are two ways to justify the use of a quadratic function. One way is to say that marginal cost of providing environmental quality is linear and increasing with respect to environment quality. First derivate of the investment cost function is $2s$. More investments are needed to improve the environmental quality as the level of environmental quality increases i.e. improving environmental quality from 0.9 to 0.95 is more expensive than improving from 0.1 to 0.15. These investment costs are due to purchase of new equipment, efforts to redesign the product or process to achieve the desired level of environmental quality. Another way is to say that quadratic function is continuous, twice differentiable, and analytically tractable. For example, these reasons had also motivated Banker et al. (1998) to use a similar functional form to model fixed production costs to provide a certain quality level.

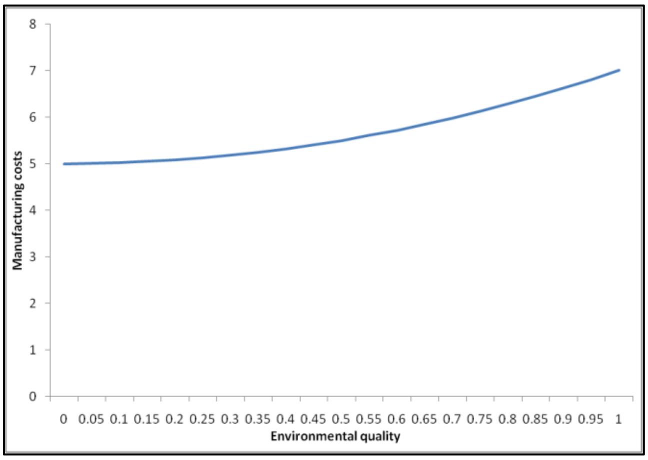
Manufacturing costs (μ_C)

$$\mu_C = \mu_{Base} + \mu s^2$$

There is always a base manufacturing cost per unit (μ_{Base}) and a variable manufacturing cost per unit (μs^2) for the quality level s. μ_{Base}, μ take non-zero positive values i.e. $\mu_{Base}, \mu > 0$. The rationale for using quadratic cost function is the same as explained above. Contrary to investment costs, it is reasonable to assume that there will be some fixed manufacturing cost

even if zero environmental quality level is provided. Manufacturing costs cannot be negative or zero. There is always some positive cost associated with manufacturing one unit. The directionality and functional form is illustrated in Figure 29 below.

Figure 29: Directionality and functional form for manufacturing costs



Procurement costs

$$Procurement\ costs = Cost\ of\ procuring\ SL + Cost\ of\ procuring\ PL$$

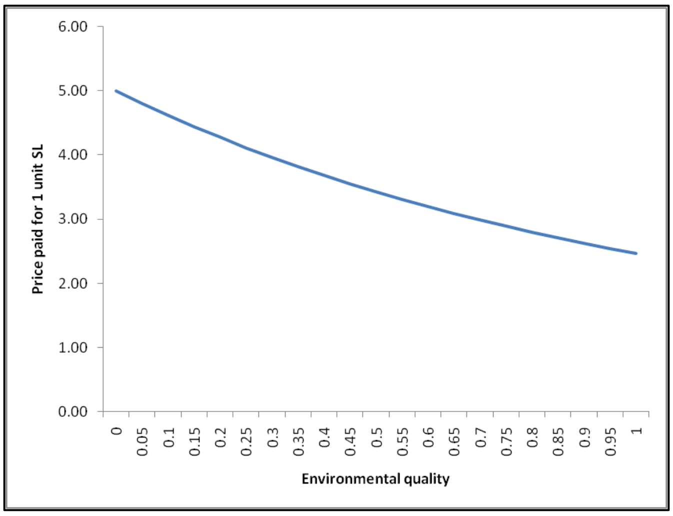
$$\begin{aligned} Procurement\ costs \\ &= (Quantity\ of\ SL\ used\ for\ making\ one\ unit \\ &* Price\ for\ one\ unit\ of\ SL) \\ &+ (Quantity\ of\ PL\ used\ for\ making\ one\ unit \\ &* Price\ for\ one\ unit\ of\ PL) \end{aligned}$$

$$Procurement\ costs = (\ q_{SL} * p_1) + (\ q_{PL} * p_2),$$

It is to be noted that $q_{SL} + q_{PL} = 1$. This denotes a total quantity of SL and PL procured from the market, which is scaled to a factor of 1.

p_1 is the price charged by R to M. If M improves s, p_1 decreases. Thus, we can model $p_1 = a_2 + b_2 e^{-s}$. The directionality and functional form is illustrated in Figure 30 below.

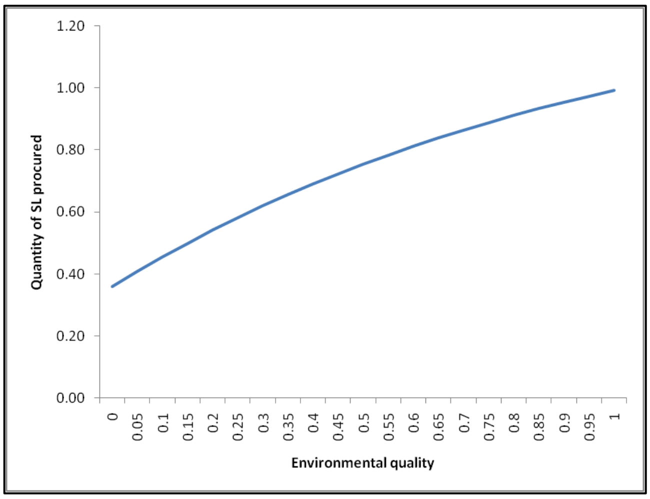
Figure 30: Directionality and functional form for SL price



a_2, b_2 are the recovery cost coefficients of R. As M improves s from 0, higher reductions in p_1 are possible for each increment in s. After some level of improvement as s tends to maximum improvement possible (i.e. as s reaches 1), the reductions in p_1 become less for each increment in s. The use of exponential function is to capture this property.

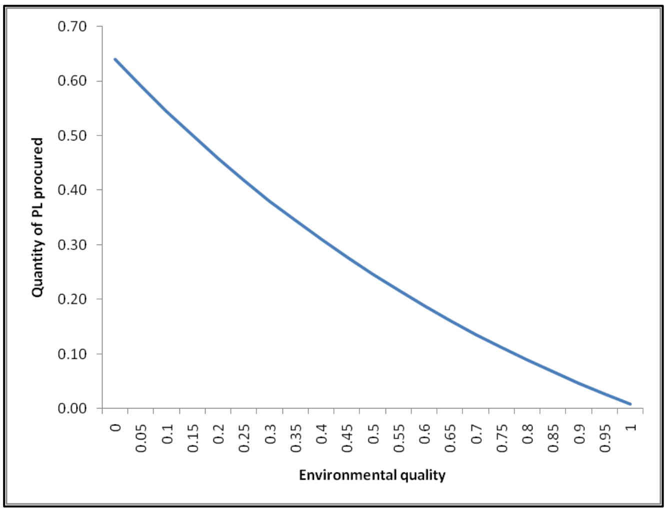
q_{SL} is the quantity of SL purchased by M from R. If M improves s, q_{SL} increases. Thus, we can model $q_{SL} = a_1 - b_1 e^{-s}$. The directionality and functional form is illustrated in Figure 31 below.

Figure 31: Directionality and functional form for SL quantity



a_1, b_1 are the recovery quantity coefficients of R. As M improves s from 0, higher quantity of q_{SL} can be recovered for each increment in s. After some level of improvement as s tends to maximum improvement possible (i.e. as s reaches 1), the quantity of q_{SL} that can be recovered becomes less for each increment in s. The use of exponential function is to capture this property. As q_{SL} increases, q_{PL} decreases. Figure 32 illustrates the functional form of q_{PL}.

Figure 32: Directionality and functional form for PL quantity



We need to decide whether to make p_2 exogenous or endogenous to our model i.e. if p_2 is influenced by the supply of SL, then p_2 will need to be endogenous to our model. As this is a base model and to keep the phenomenon simple we assume p_2 to be exogenous (this assumption can be modified as we extend and enrich the base model based on data from field study). It is also possible that manufacturer can opt for fixed-price contracts for purchasing primary lead from domestic primary lead mining companies.

Thus, procurement costs = $(a_1 - b_1 e^{-s})(a_2 + b_2 e^{-s}) + (1 - a_1 + b_1 e^{-s})p_2$

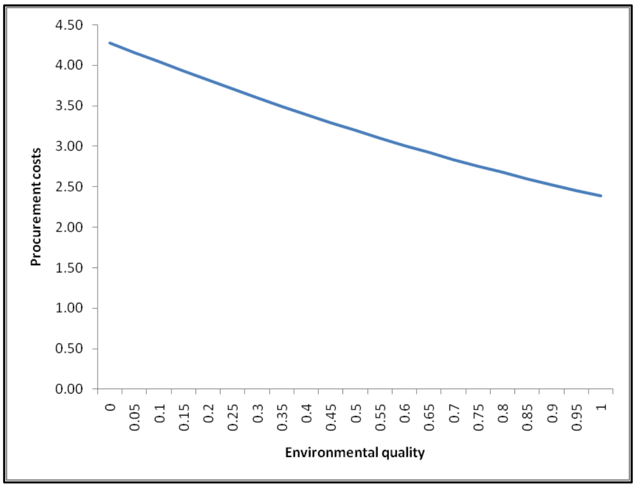
What values can a_1, b_1, a_2, b_2, p_2 take?

$$\left.\begin{array}{c} a_1, b_1 > 0 \\ a_1 > b_1 \\ b_1 > e^s(a_1 - 1) \end{array}\right\}$$ This will ensure than q_{SL}, q_{PL} is always greater

$$\left.\begin{array}{c} a_2 \geq 0 \\ b_2 > 0 \end{array}\right\}$$ This will ensure than p_1 is always greater than zero

$a_2 + b_2 e^{-s} < p_2$ (This says that price of per unit SL is always less than the price of per unit PL). The directionality and functional form of procurement cost function is illustrated in Figure 33 below.

Figure 33: Directionality and functional form for procurement costs



Processing costs

$$Processing\ costs = Cost\ of\ processing\ SL\ +\ Cost\ of\ processing\ PL$$

$$\begin{aligned} Processing\ costs \\ &= (Quantity\ of\ SL\ used\ for\ making\ one\ unit \\ &* \ Processing\ cost\ for\ one\ unit\ of\ SL) \\ &+ \ (Quantity\ of\ PL\ used\ for\ making\ one\ unit \\ &* \ Processing\ cost\ for\ one\ unit\ of\ PL) \end{aligned}$$

$$Processing\ costs = \ (\ q_{SL} * c_1) + (\ q_{PL} * c_2)$$

$$i.e.\ Processing\ costs = \ (a_1 - b_1 e^{-s})c_1 + (1 - a_1 + b_1 e^{-s})c_2$$

What values can a_1, b_1, c_1, c_2 take? Constraints on a_1, b_1 are the same as above.

$$c_1, c_2 > 0$$

$$c_1 > \ c_2$$

The various forces (cost components) acting on M when it decides to improve environmental quality are as follows: Investment costs increases, manufacturing costs increases, purchase

price of SL decreases, purchase quantity of SL increases, purchase quantity of PL decreases, processing costs of SL increases, and processing costs of PL decreases.

(3) Optimization and analysis

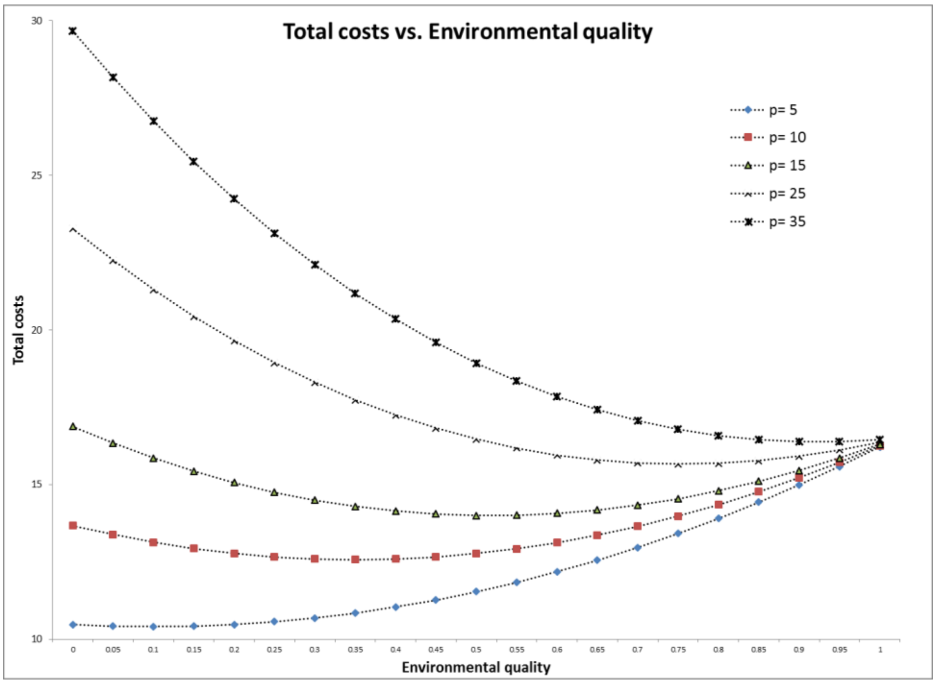
$$\begin{aligned} Total\ costs\ per\ unit\ for\ M \\ &= Is^2 + \mu_{Base} + \mu s^2 + \ (a_1 - b_1 e^{-s})(a_2 + b_2 e^{-s}) + (1 - a_1 + b_1 e^{-s})p_2 \\ &+ (a_1 - b_1 e^{-s})c_1 + (1 - a_1 + b_1 e^{-s})c_2 \end{aligned}$$

Taking the first partial derivative with respect to s and equating to zero, we get the following:

$$b_1 c_1 e^{-s} - b_1 c_2 e^{-s} - b_2 e^{-s}(a_1 - b_1 e^{-s}) + b_1 e^{-s}(a_2 + b_2 e^{-s}) - b_1 e^{-s} p_2 + 2Is + 2\mu s = 0$$

It is evident from the above equation (first derivative of the total costs curve) that it is difficult to solve for s. Hence, obtaining a closed-form solution is not possible. This makes us to resort to doing simple numerical analysis to understand how sensitive the total costs curve with respect to certain parameters is. The behavior of total costs w.r.t environmental quality when market price of PL increases is interesting. Figure 34 illustrates this relationship. This is drawn by assuming some basic values for other parameters and keeping them constant.

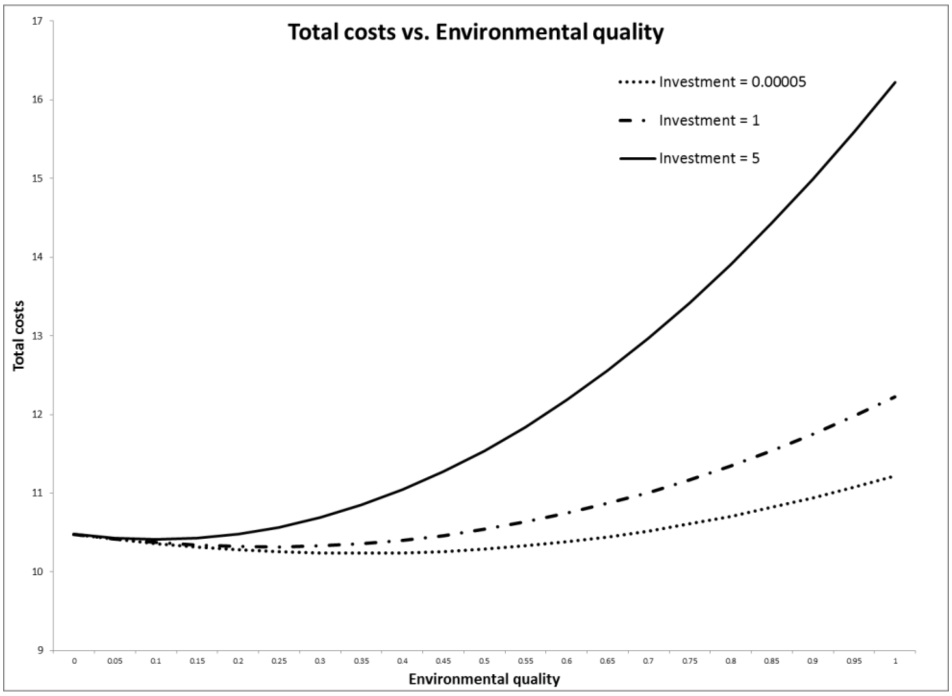
Figure 34: Total costs w.r.t environmental quality when market price of PL increases



When market price of PL is low, there is no incentive for M to increase environmental quality because M can always procure PL at low prices without worrying about the price of SL sold by R. But, when market price of PL increases, M can lower his total costs by increasing the environmental quality of the product. Increasing environmental quality helps M to reduce his procurement costs of SL from R. Though the processing costs, investment costs, and manufacturing costs increase, a high reduction in procurement costs offsets this. When p_2= 15, we can see that the total cost curve becomes more convex and an optimal level of environmental quality is achievable. The implication of this for policy maker is as follows. The policy maker can incentivize M to increase the environmental quality of product by manipulating the price paid by M to procure PL. Some examples are imposing import duties for importing PL, an environment tax for purchasing PL from domestic PL manufacturing companies, etc.

The behavior of total costs w.r.t environmental quality when investment costs increase is another interesting observation. Figure 35 illustrates this relationship. This is drawn by assuming some basic values for other parameters and keeping them constant.

Figure 35: Total costs w.r.t environmental quality when investment costs increase



When investment for providing environmental quality is low, the total cost curve is less convex i.e. M has an incentive to lower the total costs by improving the environmental quality. When investment for providing environmental quality increases, the optimal environmental quality

decreases i.e. M will not be able to reduce the total costs by improving environmental quality because the high investment costs offsets reduction in procurement costs. These cost curves have assumed a constant low value for the market price of PL. If the market price of PL increases, M will be able to reduce the total costs by improving environmental quality in spite of high investment costs. Keeping this idea of high market price of PL aside, we still have some interesting observations for policy makers. The policy maker can increase the environmental quality of product by controlling the investment costs indirectly. An example is providing subsidy or import waivers to M for purchasing or importing equipment/machinery (investment costs) that provides environmental quality. The policy maker can also decide to subsidize the recovery cost of R. This may enable M to procure more SL from R and reduce procurement of PL from market. But, this need not incentivize M to improve environmental quality. The policy maker also can think of subsiding recovery costs of R and subsidizing investment costs of M. The key policy options are summarized below:

- The policy maker can incentivize M to increase the environmental quality of product by dis-incentivizing M to procure PL. Some examples are imposing import duties for importing PL, or an environment tax for purchasing PL from domestic PL manufacturing companies.
- The policy maker can incentivize M to increase the environmental quality of product by controlling the investment costs indirectly. One example is to provide subsidy or import waivers to M for purchasing or importing equipment/machinery (investment costs) that provides environmental quality.

These analyses are preliminary and show that there are policy options that can be designed for incentivizing M to improve environmental quality that minimizes total costs. This analysis can be extended by collecting numerical data from a Manufacturer (M), Recycler (R) for a single product category (i.e. circuit boards from mobile phones) and using the numerical data to simulate the model or do sensitivity analysis.

7.3.3 Avenues for future research in analytical modeling

Here, let us discuss the possible enhancements regarding the QUARTZ project (i.e. the part of the RSC where Informal Processors, Formal Processors, and Precious Metal Refiner interacts). This model studies the interactions/trade-offs between key variables using parsimonious

assumptions grounded in field evidence. This is consistent with the calls made by senior OM scholars to build "grounded" analytical models (Choi & Guide, 2011). In doing this, we do not claim that this simple model captures the complexity of e-waste RSC. This model can be extended in many ways to capture the complexity of e-waste RSC. For example, commodity prices in the real-word is volatile at a daily-level. This volatility could be factored in by using an appropriate random variable distribution with carefully chosen mean and standard deviation. Another possible extension is to "play with" various functional forms for $q_i(\alpha)$. One may use a piece-wise linear form, to characterize how q_i changes with α. But, playing with such functional forms would need to be preceded by a systematic field study of this three-tiered supply chain (in the spirit to build grounded analytical models).

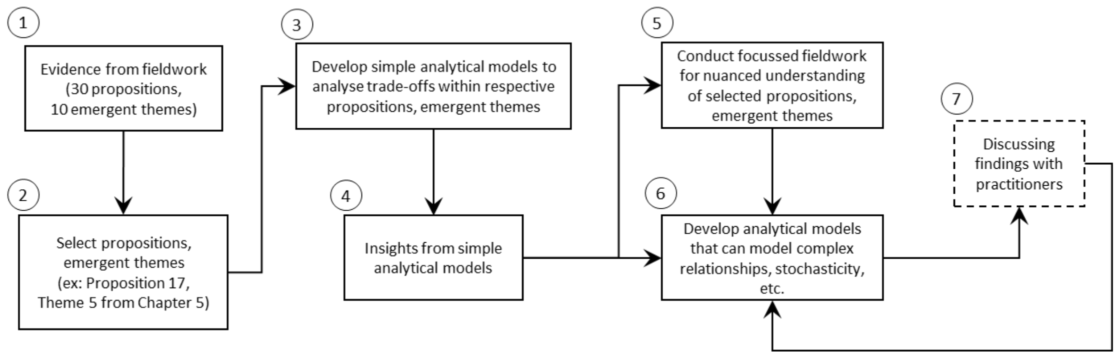
Another potential extension, would be to focus on the interaction between F and PMR. What happens between F and PMR is as follows. In a typical one-shot transaction, F would aggregate shredded circuit boards to fill one container. Based on the type of circuit boards collected, F would have an estimate regarding quantity and type of metals that can be extracted from the container. F takes a random sample from the container and ships to PMR. This sample is inspected by a third party, authorized by PMR, to estimate quantity and type of metals that can be extracted from the container based on this sample. PMR provides this information to F. Based on this, F decides whether to ship the container to PMR or not. F ships the container to PMR for metal recovery at Period 1. PMR receives the shipment at Period 2, does metal recovery from shredded circuit boards at Period 3 (this is because, availability of other raw materials like catalytic converters are important to start metal recovery process from shredded circuit boards). After the metal recovery is complete at Period 3, PMR is able to know the exact quantity and type of metals that could be recovered from the container. This can be some percentage above or below the estimates. PMR conveys this information to F and F would need to "believe" whatever PMR says. There is no way for F to ascertain the exact quantity and type of metals recovered. Though there are a few precious metal refiners (like Umicore, Mitsubishi, Cimelia, Sims) it is not possible for F to look for the best rates and ship shredded circuit boards. A discerning researcher can propose to F, to exhibit the supplier power owing to manual disassembly of circuit boards into pure waste streams. F can then offer a menu of contracts and precious metal refiners (who are more knowledgeable regarding quantity and type of metals that can be recovered) would self-select. *The key question we can ask is this: <u>Can F devise intelligent contract such that PMR reports the true quantity of type of metals that could be</u>*

extracted? In the language of game theory, this would turn out to the Principal (i.e. F) devising some kind of screening contracts for the Agent (i.e. PMR) in the presence of information asymmetry and uncertain yield.

Another example to extend this model would be to incorporate derivatives. Having rigorously understood the phenomenon, derivative instruments (ex: futures contract, put options, etc.) can be introduced to incentivize Informal Processors register themselves and use exchanges to sell the hazardous printed circuit boards to players like PMR. In another industry context (rubber industry in Kerala), this has been worked out (Singh, 2012). The small rubber growers in Kerala were encouraged to form a co-operative and hedge their price risk. There were giant live ticker boards installed in the neighborhood. This enabled all members to see the real-time movement of prices.

To conclude, in this section we have built simple analytical models from the description of e-waste RSC (drawn from our qualitative study). We have also shown how such simple models can be further extended to capture the nuances of market phenomena and industry context. In essence, our approach is illustrated in the figure below.

Figure 36: The process of constructing analytical models



This process of constructing analytical models is consistent with the ideas expressed by OM scholars (Choi & Guide, 2011; Holguín-Veras et al., 2013; Besiou & Wassenhove, 2015). We have executed steps 1, 2, 3, and 4, shown in Figure 36, through sections 7.3.1 and 7.3.2. Avenues for future research lays the path for executing steps 5 and 6. As is the case with any lasting analytical model, the results/findings would need to be discussed with practitioners for sustaining the practical relevance of academic research. For example, consider the case of contracts with asymmetric information. The findings could be discussed with Formal

Processors to figure out if such contracts would make sense to them in the real-world i.e. by developing such contracts, is there a benefit for the Formal Processor to change the way business is being done. This would help achieve the approach of pursing industry studies research that are driven by understanding rich phenomena that is situated with an industry context.

Epilogue

A well-educated policy expert, with masters and doctoral degrees from prestigious universities, visits a hot-spot of informal e-waste processing operations. Seeing the unsafe, unscientific nature of e-waste processing, he says to an Informal Processor: *"Hey! What you are currently doing is bad for your health and our environment…e-waste has hazardous chemicals like hexavalent chromium, arsenic, cadmium, etc. that will harm your health affect our environment…you should not be doing this way… this is illegal as per Government Rules…you should become Formal"*. The Informal Processor listens to him silently and continues to do his work.

Few days after giving this advice, this policy expert participates (upon invitation) in an International Conference on Sustainability. This conference is hosted at a reputed university and other stakeholders (including Informal Processors, Government Officials, NGOs, Formal Processors, etc.) are also invited to attend. During this conference, in the session on e-waste, this policy expert talks about how Informal Processors are polluting the environment, damaging their health, and how hard he is trying to encouraging Informal Processors to become Formal. The well-educated audience attending the seminar lauds his efforts and gives a round of applause after his PowerPoint presentation. After this session, the policy expert hurriedly comes outside the conference room, takes the tea being served and goes to a less-crowded corner in the university.

The policy expert has tea on one hand and cigarette on the other hand. He lights the cigar, starts smoking, and drinks tea[62]. The Informal Processor, who was invited to attend this conference, also takes the tea being served and notices this policy expert. He walks to him slowly and says: *"Sir, what you are currently doing is bad for your health and our environment… cigarette butts have high concentration of toxic compounds such as nicotine, tar, arsenic, chromium, cadmium, etc.[63]…you should not be doing this way…smoking in places like these, is illegal as per Government Rules…you should quit smoking or start using e-cigarettes."* The e-waste policy expert stands perplexed!

[62] This is scenario is part non-fiction and is motivated from a real-life incident with an e-waste policy expert.
[63] Healton, C. G., Cummings, K. M., O'connor, R. J., & Novotny, T. E. (2011). Butt really? The environmental impact of cigarettes. *Tobacco Control*, *20*(Suppl 1), i1-i1.

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Appendix 1: Introduction letter to motivate respondents to participate in interview

L S Murty
Professor
Production & Operations Management Area

[*Date*]

Sub: Research on e-waste management in India by Mr. T S Krishnan

Dear Sir/Madam,

Mr. T S Krishnan [ts.krishnan10@iimb.ernet.in ; mobile: 9740xxxxxx], a research scholar at IIM Bangalore, is conducting doctoral research on e-waste (discarded electrical and electronic products including lead acid batteries) management. Mr. Krishnan's research is supervised by the Institute's faculty: Prof. L S Murty, Prof. Damodaran A, and Prof. Anshuman Tripathy. The purpose of this study is to learn and understand how e-waste is being managed in India. For achieving this purpose, we are interacting with various people who have experience in managing e-waste.

We are interested to know about e-waste management from your experience. The information obtained from you will help us enrich our research in understanding how e-waste is being / has to be managed in our country.

The interaction with you will be recorded, with your permission, to obtain an accurate report. If you wish to speak "off-the-record", the recording device will be turned off. Summary/transcript of this interaction, with the names and firms kept anonymous, will be sent to you for your perusal. The information will be kept confidential and used only for academic research purposes. Aggregate findings of this study will be publicly available in IIM Bangalore library and can be shared with you, if you so wish.

We appreciate your time and efforts for permitting us to interact with you.

Yours Sincerely,

[*Signature*] [*Signature*]

(L S Murty) (T S Krishnan)
Phone: +91-80-26993044 (O)
E-mail: lsmurty@iimb.ernet.in

Appendix 2: Hindi version of the revised structure of inquiry

Structure of inquiry to understand e-waste RSC

Stage in the RSC	Level 2 questions (mental line of inquiry)	Level 1 questions (verbal line of inquiry)
Sources		ये e-waste क्या होता हे ? आप कुछ example (उदाहरण) दे सकते हे ?
	-What are the different sources of e-waste? Retail consumers, bulk consumers, manufacturers, and others?	e-waste कहाँ से आता हे ? यानि e-waste का स्रोत (आग़ाज़) क्या हे ?
	-Is there a relation between type of source and type of e-waste? -What is that relation?	इन जगाहों से, किस type (तरह) के e-waste आते हे ?
	-Do these sources purchase differently?	इन जगाहों, कैसे उन्हें खरीदते हे ?
	-What disposal options do they have? -How do they decide a particular disposal option? -How do retailers, manufacturers, formal processors, door-to-door collectors and scrap dealers collect e-waste from the various sources? -Is there a relation between type of e-waste and disposal option? -What is that relation?	ये सभी जगाहों (स्रोत / आग़ाज़), e-waste को कैसे फेकते हे ? क्या ये सभी type (तरह) के e-waste, इन तरीकों से फैके जाते हे ?
	-How is the economic value of products determined during disposal? -Products, information, and funds flow during disposal?	ये लेन-देन (लेना-देना), कैसे होता हे ? - क्या क्या item (materials / चीझ) या products (उत्पादों) ? - किन दामों (prices / कीमतों) पर ? - ये दामों (prices) कैसे decide (तय) होती हे ? यानि इन कीमतों का फ़ैसला कैसे होता हे ?
Collectors	-After purchasing e-waste from sources, to whom do the collectors sell? -Why do they sell?	आगे क्या होता हे ? कैसे होता हे ?
	-How is the economic value of products determined in this transaction? -Products, information, and funds flow during this transaction?	ये लेन-देन (लेना-देना), कैसे होता हे ? - क्या क्या item (materials / चीझ) या products (उत्पादों) ? - किन दामों (prices / कीमतों) पर ? - ये दामों (prices) कैसे decide (तय) होती हे ? यानि इन कीमतों का फ़ैसला कैसे होता हे ?

Processors	-How does formal processors and informal processors purchase e-waste from collectors? i.e. to whom does collectors sell e-waste? -Why do they sell? -Retailers, dealers, manufacturers, informal processors, formal processors, scrap dealers, door-to-door collectors are individual profit-maximising stakeholders? -Is there any interaction between formal and informal processors? Why?	उसके बाद क्या होता हे ? कैसे होता हे ?
	-How is the economic value of products determined in this transaction? -Products, information, and funds flow during this transaction?	ये लेन-देन (लेना-देना), कैसे होता हे ? - क्या क्या item (materials / चीझ) या products (उत्पादों) ? - किन दामों (prices / कीमतों) पर ? - ये दामों (prices) कैसे decide (तय) होती हे ? यानि इन कीमतों का फ़ैसला कैसे होता हे ?
Processing operations	-The five e-waste processing operations -Are there other processing operations? What are they?	ये e-waste को क्या करते हे (process / recycle)? यानि उस्का तरीका क्या हे ?
	-Are all processing operations done by a single processor? Or is there specialisation in processing operations?	ये तरीके (process / recycle), कौन कौन करते हे ?
	-How do the processors choose a particular processing operation for a product? Based on functionality, modularity, and demand in second hand-market?	एक तरीका करना है या नहीं करना है…ये कैसे decide (तय) करते हे ?
	-Formal processors: The specific technology used, fixed costs, variable costs, inputs and outputs? -Informal processors: The specific technology used, fixed costs, variable costs, inputs and outputs? -Difference in the quality of outputs between formal and informal processors?	आपके हिसाब से, ये तरीके (process / recycle) करने मे, क्या क्या खर्च आते हे ? क्या सभी recyclers को बराबर (same / एक जैसा) खर्च होता हे ? क्या सभी recyclers का output (तैयार माल / उत्पादन) बराबर (same / एक जैसा) होता हे ?
	-Which processing operations of informal processors create negative externalities? Why? -Do processing operations of formal processors create negative externalities? Why?	ये तरीके (process / recycle), सेहत (health / स्वास्थ्य) और आसपास के हवा- पानी (environment / वातावरण) पे क्या फरक (असर) पड़ता हे ?
Final destinations	-How e-waste parts/materials reach secondary smelters, second-hand markets, manufacturers, metal markets, and landfill after processing?	आगे क्या होता है ? कैसे होता है ?

	-How is the economic value of products/materials determined in this transaction? -Products, information, and funds flow during this transaction?	ये लेन-देन (लेना-देना), कैसे होता हे ? - क्या क्या item (materials / चीझ) या products (उत्पादों) ? - किन दामों (prices / कीमतों) पर ? - ये दामों (prices) कैसे decide (तय) होती हे ? यानि इन कीमतों का फ़ैसला कैसे होता हे ?
	-Are these materials used in the manufacture of same products to same set of consumers (i.e. sources of e-waste)?	वो लोग, फिर क्या क्या करते हे ?
Emergent questions	Is the recycling/processing value decreasing over the years, increasing over the years, or neutral? Why?	इन कई सालों से, आपके experience (अनुभव) से…e-waste से कमाई जो होता हे…उसको क्या हो रहा हे ?
	Are all products/brands easy to process? Any products/brands that are difficult to process? Why? Is it due to design modularity i.e. modular products are easy to process when compared to integral products.	इन कई सालों से, आपके experience (अनुभव) से… e-waste से कमाई और company में कोई सम्बद्ध हे? यानी किसी company के माल से आसानी से कमाई कर सकते हे, parts निकाल सकते हे, किसी और company के माल से कमाई करना, parts निकालना मुश्किल हे… किसी company के माल आसानी से बिक जाता हे …. ज़्यादा पैसा मिलता हे… क्यों ?
	Weight of products decreasing? High value material substituted with low value materials? (ex: aluminium or steel substituted with plastic, etc.) Product design becoming more integral/modular?	आप के हिसाब (अनुसार / विचार) से, products के बनावट (design) में कुछ बदलाव आया हे ? यानी सामग्री (material) में कुछ बदलाव…अन्दर के parts में कुछ बदलाव…या कुछ और ? क्यों ?

General	-Are the activities in the RSC decentralised? Why? - Is the RSC described same throughout India?	क्या कुछ ऐसी तरीका (process / recycle) भी हे, जो कुछ शहरों या इलाकों में होती हे ? वो कैसे होता हे ?
	-How did EMHR impact e-waste RSC? -New links created? Old links destroyed?	e-waste rules (कानुन / नियम) के साथ आपका experience (अनुभव) कैसा रहा ?
	This is to encourage interviewees to volunteer information which interviewer may not have thought about.	आप के हिसाब (अनुसार / विचार) से, और कुछ जानकारी हे e-waste के बारे में जो मुझे जाहना चाहिये ?

<u>Alternate set of questions to new stakeholders (if any)</u>

आपके कच्चे माल क्या क्या हे ? वो कहाँ से आता हे ? ये लेन-देन (लेना-देना), कैसे होता हे ?

इस कच्चे माल से क्या करते हे ? क्या उत्पादन किया जाता है ? ये किसको भेजते हे ? ये लेन-देन (लेना-देना), कैसे होता हे ?

Structure of inquiry for individual stakeholders to understand e-waste RSC

Stage in the RSC	**Level 2 questions (mental line of inquiry)**	**Level 1 questions (verbal line of inquiry)**
Sources		ये e-waste क्या होता हे ? आप कुछ example (उदाहरण) दे सकते हे ?
	-What are the different sources of e-waste? Retail consumers, bulk consumers, manufacturers, and others?	
	-Is there a relation between type of source and type of e-waste? -What is that relation?	आपका company में किस type (तरह) के e-waste होता हे ?
	-Do these sources purchase differently?	आपका company कैसे उन्हें खरीदते हे ?
	-What disposal options do they have? -How do they decide a particular disposal option? -How do retailers, manufacturers, formal processors, door-to-door collectors and scrap dealers collect e-waste from the various sources? -Is there a relation between type of e-waste and disposal option? -What is that relation?	आपका company, e-waste को कैसे फेकते हे ? क्या ये सभी type (तरह) के e-waste, इन तरीकों से फैके जाते हे ?
	-How is the economic value of products determined during disposal? -Products, information, and funds flow during disposal?	ये लेन-देन (लेना-देना), कैसे होता हे ? - क्या क्या item (materials / चीझ) या products (उत्पादों) ? - किन दामों (prices / कीमतों) पर ?

		- ये दामों (prices) कैसे decide (तय) होती हे ? यानि इन कीमतों का फ़ैसला कैसे होता हे ?
Collectors	-After purchasing e-waste from sources, to whom do the collectors sell? -Why do they sell?	ये e-waste क्या होता हे ? आप कुछ example (उदाहरण) दे सकते हे ? आपका company कैसे e-waste को collect (इकट्ठा) करता हे ? किस type (तरह) के e-waste को collect (इकट्ठा) करते हे ?
	-How is the economic value of products determined in this transaction? -Products, information, and funds flow during this transaction? -How does formal processors and informal processors purchase e-waste from collectors? i.e. to whom does collectors sell e-waste? -Why do they sell? -Retailers, dealers, manufacturers, informal processors, formal processors, scrap dealers, door-to-door collectors are individual profit-maximising stakeholders? -Is there any interaction between formal and informal processors? Why? -How is the economic value of products determined in this transaction? -Products, information, and funds flow during this transaction?	ये लेन-देन (लेना-देना), कैसे होता हे ? - क्या क्या item (materials / चीझ) या products (उत्पादों) ? - किन दामों (prices / कीमतों) पर ? - ये दामों (prices) कैसे decide (तय) होती हे ? यानि इन कीमतों का फ़ैसला कैसे होता हे ? e-waste collect (इकट्ठा) करने के बाद, क्या होता हे ? कैसे होता हे ? ये लेन-देन (लेना-देना), कैसे होता हे ? - क्या क्या item (materials / चीझ) या products (उत्पादों) ? - किन दामों (prices / कीमतों) पर ? - ये दामों (prices) कैसे decide (तय) होती हे ? यानि इन कीमतों का फ़ैसला कैसे होता हे ?
	Weight of products decreasing? High value material substituted with low value materials? (ex: aluminium or steel substituted with plastic, etc.) Product design becoming more integral/modular?	आप के हिसाब (अनुसार / विचार) से, products के बनावट (design) में कुछ बदलाव आया हे ? यानी सामग्री (material) में कुछ बदलाव…अन्दर के parts में कुछ बदलाव…या कुछ और ?

		क्यों ?
	Are all products/brands easy to process? Any products/brands that are difficult to process? Why? Is it due to design modularity i.e. modular products are easy to process when compared to integral products.	इन कई सालों से, आपके experience (अनुभव) से… e-waste से कमाई और company में कोई सम्बद्ध हे ? यानी किसी company के माल से आसानी से कमाई कर सकते हे, parts निकाल सकते हे, किसी और company के माल से कमाई करना, parts निकालना मुश्किल हे… किसी company के माल आसानी से बिक जाता हे …. ज़्यादा पैसा मिलता हे… क्यों ?
	Is the recycling/processing value decreasing over the years, increasing over the years, or neutral? Why?	इन कई सालों से, आपके experience (अनुभव) से…e-waste से कमाई जो होता हे… उसको क्या हो रहा हे ?
Processors	-How does formal processors and informal processors purchase e-waste from collectors? i.e. to whom does collectors sell e-waste? -Why do they sell? -Retailers, dealers, manufacturers, informal processors, formal processors, scrap dealers, door-to-door collectors are individual profit-maximising stakeholders? -Is there any interaction between formal and informal processors? Why?	ये e-waste क्या होता हे ? आप कुछ example (उदाहरण) दे सकते हे ? आपका company कैसे e-waste को collect (इकट्ठा) करता हे ? किस type (तरह) के e-waste को collect (इकट्ठा) करते हे ?
	-How is the economic value of products determined in this transaction? -Products, information, and funds flow during this transaction?	ये लेन-देन (लेना-देना), कैसे होता हे ? - क्या क्या item (materials / चीझ) या products (उत्पादों) ? - किन दामों (prices / कीमतों) पर ? - ये दामों (prices) कैसे decide (तय) होती हे ? यानि इन कीमतों का फ़ैसला कैसे होता हे ?
	-The five e-waste processing operations -Are there other processing operations? What are they?	ये e-waste को कैसे process (recycle) करते हे ? यानि उसका तरीका (method) क्या हे ?

	-Are all processing operations done by a single processor? Or is there specialisation in processing operations?	
	-How do the processors choose a particular processing operation for a product? Based on functionality, modularity, and demand in second hand-market?	एक तरीका करना है या नहीं करना है…ये कैसे decide (तय) करते हे ?
	-Formal processors: The specific technology used, fixed costs, variable costs, inputs and outputs? -Informal processors: The specific technology used, fixed costs, variable costs, inputs and outputs? -Difference in the quality of outputs between formal and informal processors?	आपके हिसाब से, ये तरीके (process / recycle) करने मे, क्या क्या खर्च आते हे ? Recycling के बाद, output (तैयार माल / उत्पादन) क्या होता हे ? यानी आप क्या supply करते हे ?
	-Which processing operations of informal processors create negative externalities? Why? -Do processing operations of formal processors create negative externalities? Why?	ये तरीके (process / recycle), सेहत (health / स्वास्थ्य) और आसपास के हवा-पानी (environment / वातावरण) पे क्या फरक (असर) पड़ता हे ?
	-How e-waste parts/materials reach secondary smelters, second-hand markets, manufacturers, metal markets, and landfill after processing?	आगे क्या होता है ? कैसे होता है ?
	-How is the economic value of products/materials determined in this transaction? -Products, information, and funds flow during this transaction?	ये लेन-देन (लेना-देना), कैसे होता हे ? - क्या क्या item (materials / चीझ) या products (उत्पादों) ? - किन दामों (prices / कीमतों) पर ? - ये दामों (prices) कैसे decide (तय) होती हे ? यानि इन कीमतों का फ़ैसला कैसे होता हे ?
	-Are these materials used in the manufacture of same products to same set of consumers (i.e. sources of e-waste)?	वो लोग इसके साथ, क्या क्या करते हे ?
	Is the recycling/processing value decreasing over the years, increasing over the years, or neutral? Why?	इन कई सालों से, आपके experience (अनुभव) से…e-waste से कमाई जो होता हे… उसको क्या हो रहा हे ?
	Are all products/brands easy to process? Any products/brands that are difficult to process? Why? Is it due to design modularity i.e. modular products are easy to process when compared to integral products.	इन कई सालों से, आपके experience (अनुभव) से… e-waste से कमाई और company में कोई सम्बद्ध हे ? यानी किसी company के माल से आसानी से कमाई कर सकते हे, parts निकाल सकते हे, किसी और company के माल से कमाई करना, parts निकालना मुश्किल हे…

		किसी company के माल आसानी से बिक जाता हे …. ज़्यादा पैसा मिलता हे… क्यों ?
	Weight of products decreasing? High value material substituted with low value materials? (ex: aluminium or steel substituted with plastic, etc.) Product design becoming more integral/modular?	आप के हिसाब (अनुसार / विचार) से, products के बनावट (design) में कुछ बदलाव आया हे ? यानी सामग्री (material) में कुछ बदलाव…अन्दर के parts में कुछ बदलाव…या कुछ और ? क्यों ?
Final destinations	-How e-waste parts/materials reach secondary smelters, second-hand markets, manufacturers, metal markets, and landfill after processing?	आपका company, कैसे raw material (कच्चा माल) को collect (purchase / इकठ्ठा) करते हे ?
	-How is the economic value of products/materials determined in this transaction? -Products, information, and funds flow during this transaction?	ये लेना-देना (लेन-देन), कैसे होता हे ? - क्या क्या materials (सामग्री / चीझ) या products (उत्पादों) ? - किन prices (कीमतों) पर ? - ये prices कैसे decide होती हे ? यानि इन कीमतों का फ़ैसला कैसे होता हे ?
	-Are these materials used in the manufacture of same products to same set of consumers (i.e. sources of e-waste)?	उसके बाद क्या होता हे ?
General	-Are the activities in the RSC decentralised? Why? - Is the RSC described same throughout India?	क्या कुछ ऐसी तरीका (process / recycle) भी हे, जो कुछ शहरों या इलाकों में होती हे ? वो कैसे होता हे ?
	-How did EMHR impact e-waste RSC? -New links created? Old links destroyed?	e-waste rules (कानुन / नियम) के साथ आपका experience (अनुभव) कैसा रहा ?
	This is to encourage interviewees to volunteer information which interviewer may not have thought about.	आपके हिसाब (अनुसार / विचार) से, और कुछ जानकारी हे e-waste के बारे में जो मुझे जाहना चाहिये ?

Structure of inquiry to understand formalization of informal e-waste processors

Stages in formalisation	Level 2 questions (mental line of inquiry)	Level 1 questions (verbal line of inquiry)
Initial conditions		ये e-waste क्या होता हे ? आप कुछ example (उदाहरण) दे सकते हे ?
	What was firm's condition before formalisation? - Sources of e-waste - Kinds of e-waste processed - Economic value, quantity, and frequency of e-waste supply	आपका company कब formalise हुआ ? यानी कब बनी (कब register करायी ? Fomalisation के पहले, आपका company कैसे काम करता था ? e-waste कहाँ से मिल रहे थे ? किस तरह के e-waste मिल रहे थे ? कितना मिल रहे थे ? कितने कितने time पे मिले रहे थे ? यानी कितनी बार मिल रहे थे ?
	What was firm's condition before formalisation? - Processing operations and negative externalities - Technology used, fixed costs, variables costs, inputs and outputs	Process (recycle) करने का तरीका (method) कैसा था ? क्या क्या तक्नीक (technology) था ? उसका खर्च क्या था ? कितना process (recycle) करते थे ? Process (recycle) के बाद, क्या करते थे ? ये तरीके (process / recycle), सेहत (health / स्वास्थ्य) और आसपास के हवा-पानी (environment / वातावरण) पे क्या फरक (असर) पड़ता था ?
	How much profits did the firm make while being informal?	Business (धंधा / व्यापार) कैसा था ?
	Why did the firm remain informal? - Exclusion view - Exit view	इस तरीके से, business (धंधा /व्यापार) कैसे होता था ?
Catalyst of change	Event or development moving the firm to pursue formalisation? What was the motivation for formalisation? Motivation came internally or externally?	आपका company, formalise करने का decision (फैसला) कैसे लिया ?

Formalisation process	What was the method of formalisation? Competitive, Cooperative, or Integrative. How did they decide the formalisation method? Content of formalisation: - Changes in processing operations - Changes in non-processing operations	Formalisation में क्या क्या हुआ था ? क्या आप detail (तफ्सील / विस्तार) में बता सकते हे ?
	Was there any external help? How did they help?	कौन कौन लोग शामिल थे ? वे कैसे शामिल किये गये ? उनकी role (काम / भूमिका) क्या थी ?
	Content of formalisation: - Changes in processing operations: fixed costs, variable costs. - Changes in non-processing operations: costs incurred.	Formalisation करने में कितना खर्च हुआ ?
Immediate outcome	What was the immediate outcome? Did profits decrease?	Formalisation के तुरंत बाद, business (धंधा / व्यापार) कैसा था ?
	What was the immediate outcome? Improved performance of processing operations? How?	Recycling तरीकों मैं change (बदलाव) कैसा रहा ?
	What was the immediate outcome? Eliminating negative externalities? How?	इस बदलाव से, सेहत (health / स्वास्थ्य) और आसपास के हवा- पानी (environment / वातावरण) पे क्या फरक (असर) पड़ा ?
Intermediate outcome	What was the intermediate outcome? - Availability of bank credit? - Business expansion? - New sources of e-waste? How much time did it take for achieving this intermediate outcome? 6 months, 1 year?	उसके बाद क्या हुआ ? Business (धंधा / व्यापार) कैसे बदला ?
Final outcome	What was the final outcome of formalisation? - New sources of e-waste? - Kinds of e-waste processed? - Economic value, quantity, and frequency of e-waste supply?	अबी आपका company कैसे काम करती हे ? यानी कैसे चलती हे ? e-waste कहाँ से मिल रहा हे? किस तरह के e-waste मिल रहे हे ? कितना मिल रहा हे ? कितने कितने time पे मिले रहा हे ? यानी कितनी बार मिल रहा हे ?
	What was the final outcome of formalisation? - What technology is used now? - What are the total formalisation related costs: fixed and variable costs? - Where does the outputs go?	अभी process (recycle) करने का तरीका क्या हे?

	- Profits? How much time did it take to achieve a stable business? 1 year, 2 years? What was the profits of formal processor in the integrative method?	खर्चा कितना आता हे ? कितना process (recycle) करते हे ? उसके बाद क्या होता हे ? अबी business (धंधा / व्यापार) कैसा हे ?
Rival explanations	Other new practices by firm that could affect the outcome of formalisation?	Formalisation के अलावा, आपकी company में कुछ और changes (बदलाव) हुआ था ?
	External market conditions: Economic value, quantity of e-waste increasing every year? This could also affect the outcome of formalisation.	Formalisation के बाद, e-waste के quantity (मात्रा) में या type में कुछ कुछ बदलाव हुआ ? बाजार में कुछ फर्क आया ?
	Influence of EMHR on outcome of formalisation?	e-waste rules (कानुन / नियम) के साथ आपका experience (अनुभव) कैसा रहा ? क्या formalisation पर e-waste rules (कानुन / नियम) का असर पडा हे ?
Formalisation challenges	To understand the formalisation related challenges. This will help us while providing recommendations.	आप के हिसाब (अनुसार / विचार) से, formalisation करने में problems (चुनौतियों / परिशानियाँ) क्या थे? … यानी क्या क्या दिक्कतें आई ? अभी क्या क्या परिशानियाँ हे ?
	This is to encourage interviewees to volunteer information which interviewer may not have thought about.	आप के हिसाब (अनुसार / विचार) से, और कुछ जानकारी हे formalisation के बारे में जो मुझे जाहना चाहिये ?

Appendix 3: Profile of respondents

Disguised name of organization	Disguised name of respondent	Stakeholder
AMO, an Electronics Retail Chain that operates at a national level.	Zonal Manager (South) of AMO	RETAILER
Retail store of AIK, a multinational mobile phone manufacturer	Center Manager of AIK's retail store	MANUFACTURER-CUM-RETAILER
Manufacturers' Association. Some manufacturers responsible for product take-back also belong to this association	Sr. Director of Manufacturers' Association	MANUFACTURER
MIB (This is a government organisation)	- Manager of the IT Department at MIB - Manager of the Electrical Department at MIB	BULK CONSUMER
STIMULUS (an Indo-European environmental organization that is funded by EU)	Consultant X of STIMULUS Consultant Y of STIMULUS Consultant Z of STIMULUS	NGO Was also involved in preparing drafts of e-waste legislation.
Bravo (an NGO focussed on solid waste management including e-waste)	Founder of Bravo	NGO
CIT (a MNC with operations in India)	Business Development Manager of CIT, a formal e-waste processor.	FORMAL E-WASTE PROCESSOR
Alpha	Proprietor of Alpha	INFORMAL-TURNED-FORMAL PROCESSOR
Poly (a Plastic Granules Manufacturer)	Proprietor of Poly	PLASTICS RECYCLER
CLEAN (an NGO focused on solid waste management and waste pickers)	Assistant Business Manager of Clean	NGO
Epsilon	Business Development Manager of Epsilon	INFORMAL-TURNED-FORMAL PROCESSOR
SEK (a scrap metal trading firm)	Informal Processor B (he is the proprietor of SEK)	INFORMAL PROCESSOR. He was initially in the informal sector. Then, he became formal. Later, he quit the formal sector and returned to informal sector.

Gamma	Joint Proprietor of Gamma	INFORMAL-TURNED-FORMAL PROCESSOR
LED (a multinational IT hardware manufacturer)	Product Take-back Manager of LED	MANUFACTURER Was also involved in preparing draft of e-waste legislation.
AIK (a multinational mobile phone manufacturer)	Sustainability Head of AIK	MANUFACTURER
Zeta	Proprietor of Zeta	INFORMAL-TURNED-FORMAL PROCESSOR
BB (a formal e-waste collection firm)	- Founder & CEO of BB - Operations Manager of BB	E-WASTE COLLECTOR (collecting from retail consumers)
Component Manufacturers' Association (components that go into an electronic product)	Managing Director of Component Manufacturers' Association	PARTS/COMPONENTS MANUFACTURER
TAT (a large-size Telecom MNC)	Retail Consumer 2 (an employee at TAT) Retail Consumer 1 (an employee at TAT)	RETAIL CONSUMER
TAT (a large-size Telecom MNC)	HR Associate with TAT	BULK CONSUMER
JAS (a scrap metal trading firm)	Informal Processor A (he is the joint proprietor of JAS)	INFORMAL PROCESSOR. He was initially in the informal sector. Then, he became formal. Later, he quit and now works independently.
Beta	Management Head of Beta	INFORMAL-TURNED-FORMAL PROCESSOR
COOL (an electronics repair and reselling firm)	Proprietor of COOL	INFORMAL PROCESSOR
Delta	Proprietor of Delta	INFORMAL-TURNED-FORMAL PROCESSOR
IMU (a Precious Metal Refiner outside India)	Sales Manager (India and Middle-East) at IMU	PRECIOUS METAL REFINER
RWM (manufacturer that makes machinery for e-waste processing)	Co-founder of RWM	E-WASTE PROCESSING MACHINERY MANUFACTURER
AMY	Co-founders of AMY	FORMAL PROCESSOR (with informal roots)

RTH	Founder of RTH	FORMAL PROCESSOR (with informal roots)
LDF (a firm that makes castings for auto industry using scrap metals and virgin metals)	HR and Purchase executives at LDF	FOUNDRY (SCRAP METAL SMELTER)
HDS (an NGO that focusses on waste pickers and their livelihoods)	Founder of HDS	NGO
4 Scrap Dealers, 1 waste sorter		WASTE COLLECTORS-CUM-SCRAP DEALERS
IMT	Proprietor of IMT	HAZARDOUS WASTE INCINERATOR
COMPOST (waste management consultancy)	Co-founder of COMPOST	EXPERT ON SOLID WASTE MANAGEMENT
TFG (a multinational metal trading firm)	Metal Trading analyst at TFG	METAL TRADER
Governmental Organization (has been closely involved in authorizing informal processors, enforcing, and monitoring compliance to e-waste legislation)	- Former Senior Officer at a Governmental Organization - Senior Officer at a Governmental Organization - Officer at a Governmental Organization	GOVERNMENT
RML (a metal casting firm)	Founder and MD of RML	SCRAP METAL TRADER-CUM-SCRAP METAL INDUSTRY EXPERT
GKN (a big formal processor)	Manager of GKN	FORMAL PROCESSOR
OIP (a large IT MNC)	Sr. Manager (Sustainability) at OIP	BULK CONSUMER
ALAN Electronics (a firm that trades on electronic products)	Business Development Executive of a formal processor (he is the proprietor of ALAN) He has deep experience in the scrap metal industry; currently works with Informal Processor A and helps to purchase e-waste for him; has also worked with other leading formal e-waste processors in business development.	FORMAL PROCESSOR; SCRAP METAL INDUSTRY EXPERT
MSB (a large IT MNC)	Officer in the IT section	BULK CONSUMER
-	A consultant to Auto Industry-cum-Recycling Enthusiast with over 25 years' experience.	

MMT (a leading importer of metal scrap)	Founder and MD of MMT (A Veteran in scrap metal trading in India)	SCRAP METAL TRADER-CUM- SCRAP METAL INDUSTRY EXPERT
VET (a recycler dealing with used oil, battery, general waste, e-waste, plastics, interior demolition, etc.)	Proprietor of VET	INFORMAL PROCESSOR

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Appendix 6: E-Waste Management and Handling Rules 2011

MINISTRY OF ENVIRONMENT AND FORESTS

NOTIFICATION

New Delhi, the 12th May, 2011

S.O. 1035(E).— Whereas, the draft rules, namely the e-waste (Management and Handling) Rules, 2010 were published by the Government of India in the Ministry of Environment and Forests vide number S.O.1125 (E), dated 14th May, 2010 in the Gazette of India, Extraordinary Part II, Section 3, Sub-section (ii) dated 14th May, 2010 inviting objections and suggestions from all persons likely to be affected thereby, before the expiry of the period of sixty days from the date on which copies of the Gazette containing the said notification were made available to the public;

AND WHEREAS the copies of the said Gazette were made available to the public on the 14th day of May, 2010;

AND WHEREAS the objections and suggestions received within the said period from the public in respect of the said draft rules have been duly considered by the Central Government;

NOW, THEREFORE, in exercise of the powers conferred by sections 6, 8 and 25 of the Environment (Protection) Act, 1986 (29 of 1986), the Central Government hereby makes the following rules, namely:-

CHAPTER I

PRELIMINARY

1. **Short title and commencement.** –

(1) These rules may be called the e-waste (Management and Handling) Rules, 2011.
(2) They shall come into effect from 1st May, 2012.

2. **Application.** – These rules shall apply to every producer, consumer or bulk consumer involved in the manufacture, sale, purchase and processing of electrical and electronic equipment or components as specified in Schedule-I, collection centre, dismantler and recycler of e-waste and shall not apply to-

(a) batteries as covered under the Batteries (Management and Handling) Rules, 2001 made under the Act;

(b) Micro and small enterprises as defined in the Micro, Small and Medium Enterprises Development Act, 2006 (27 of 2006); and

(c) radio-active wastes as covered under the provisions of the Atomic Energy Act, 1962 (33 of 1962) and rules made there under.

3. **Definitions.** – (1) In these rules, unless the context otherwise requires, -

(a) 'Act' means the Environment (Protection) Act, 1986 (29 of 1986);

(b) 'authorisation' means permission for handling, collection, reception, storage, transportation, dismantling, recycling, treatment and disposal of e-waste granted under sub-rule (3) of rule 9;

(c) 'bulk consumer' means bulk users of electrical and electronic equipment such as Central Government or State Government Departments, public sector undertakings, banks, educational institutions, multinational organizations, international agencies and private companies that are registered under the Factories Act, 1948 and Companies Act, 1956;

(d) 'central pollution control board' means the Central Pollution Control Board constituted under sub-section (1) of section 3 of the Water (Prevention and Control of Pollution) Act, 1974 (6 of 1974);

(e) 'collection centre' means a centre established, individually or jointly or a registered society or a designated agency or a company or an association to collect e-waste;

(f) 'consumer' means any person using electrical and electronic equipment excluding the bulk consumers;

(g) 'dismantler' means any person or registered society or a designated agency or a company or an association engaged in dismantling of used electrical and electronic equipment into their components;

(h) 'disposal' means any operation which does not lead to recycling, recovery or reuse and includes physico-chemical or biological treatment, incineration and deposition in secured landfill;

(i) 'environmentally sound management of e-waste' means taking all steps required to ensure that e-waste are managed in a manner which shall protect health and environment against any adverse effects, which may result from hazardous substance contained in such wastes;

(j) 'electrical and electronic equipment' means equipment which is dependent on electric currents or electro-magnetic fields to be fully functional;

(k) 'e-waste' means waste electrical and electronic equipment, whole or in part or rejects from their manufacturing and repair process, which are intended to be discarded;

(l) 'extended producer responsibility' means responsibility of any producer of electrical or electronic equipment, for their products beyond manufacturing until environmentally sound management of their end-of-life products.

(m)'facility' means any location wherein the process incidental to the collection, reception, storage, segregation, refurbishing, dismantling, recycling, treatment and disposal of e-waste are carried out;

(n) 'Form' means form appended to these rules;

(o) 'historical e-waste' means e-waste generated from electrical and electronic equipment as specified in Schedule I, which was available on the date from which these rules come into force;

(p) 'orphaned products' means non branded or assembled electrical and electronic equipment as specified in Schedule I or those produced by a company, which has closed its operations or has stopped product support;

(q) 'producer' means any person who, irrespective of the selling technique used;

(i) manufactures and offers to sell electrical and electronic equipment under his own brand; or

(ii) offers to sell under his own brand, assembled electrical and electronic equipment produced by other manufacturers or suppliers; or

(iii) offers to sell imported electrical and electronic equipment;

(r) 'recycler' - means any person who is engaged in recycling or reprocessing of used electrical and electronic equipment or assemblies or their component;

(s) 'Schedule' means the Schedule appended to these rules;

(t) 'State Government in relation to a Union territory' means, the Administrator thereof appointed under article 239 of the Constitution;

(u) 'state pollution control board'- means the concerned State Pollution Control Board or the Pollution Control Committee of the Union Territories constituted under sub-section (1) of section 4 of the Water (Prevention and Control of Pollution) Act, 1974;

(v) 'transporter' means a person engaged in the off-site transportation of e-waste by air, rail, road or water

(2) Words and expressions used in these rules and not defined but defined in the m Act shall have the meanings respectively assigned to them in that Act.

CHAPTER II

RESPONSIBILITIES

4. **Responsibilities of the producer.** – The producer of electrical and electronic equipment listed in Schedule I shall be responsible for,-

(1) collection of e-waste generated during the manufacture of electrical and electronic equipment and channelizing it for recycling or disposal;

(2) collection of e-waste generated from the 'end of life' of their products in line with the principle of 'Extended Producer Responsibility' and to ensure that such e-wastes are channelized to registered dismantler or recycler. Producer shall, as necessary, ensure collection and channelization by authorizing collection agencies;

(3) setting up collection centers or take back systems either individually or collectively;

(4) financing and organizing a system to meet the costs involved in the environmentally sound management of e-waste generated from the 'end of life' of its own products and historical waste available on the date from which these rules come into force. The financing arrangement of such a system shall be transparent. The producer may choose to establish such a system either individually or by joining a collective scheme;

(5) providing contact details such as address, telephone numbers/helpline number of authorized collection centers to consumer(s) or bulk consumer(s) so as to facilitate return of used electrical and electronic equipment;

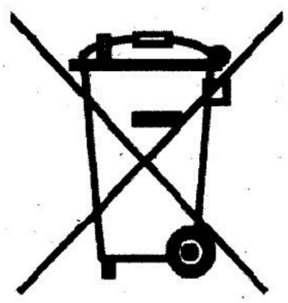
(6) creating awareness through publications, advertisements, posters, or by any other means of communication and information booklets accompanying the equipment, with regard to-

(i) information on hazardous constituents as specified in sub-rule 1 of rule 13 in electrical and electronic equipment;

(ii) information on hazards of improper handling, accidental breakage, damage and/or improper recycling of e-waste;

(iii) instructions for handling the equipment after its use, along with the Do's and Don'ts;

(iv) affixing a visible, legible and indelible symbol given below on the products or information booklets to prevent e-waste from being dropped in garbage bins containing waste destined for disposal;



(7) obtaining an authorization from the concerned State Pollution Control Board or Pollution Control Committee in accordance with the procedure under rule 9;

(8) maintaining records in Form 2 of the e-waste handled and make such records available for scrutiny by the State Pollution Control Board or the Committee concerned.

(9) filing annual returns in Form 3, to the State Pollution Control Board or Pollution Control Committee concerned, on or before the 30th day of June following the financial year to which that return relates.

5. **Responsibilities of collection centers** –Collection centre shall-

(1) obtain an authorization in accordance with the procedure under rule 9 from the State Pollution Control Board or Pollution Control Committee concerned as the case may be and provide details such as address, telephone numbers/helpline number, e-mail, etc. of such collection centre to the general public;

(2) ensure that the e-waste collected by them is stored in a secured manner till it is sent to registered dismantler(s) or recycler(s) as the case may be;

(3) ensure that no damage is caused to the environment during storage and transportation of e-waste;

(4) file annual returns in Form 3, to the State Pollution Control Board or Pollution Control Committee concerned on or before the 30th day of June following the financial year to which that return relates; and

(5) maintain records of the e-waste handled in Form 2 and make such records available for scrutiny by the State Pollution Control Board or the Pollution Control Committee concerned.

6. **Responsibilities of consumer or bulk consumer. –**

(1) Consumers or Bulk consumers of electrical and electronic equipment listed in Schedule I shall ensure that e-waste generated by them is channelised to authorized collection center(s) or registered dismantler(s) or recycler(s) or is returned to the pick-up or take back services provided by the producers; and

(2) bulk consumers shall maintain records of e-waste generated by them in Form 2 and make such records available for scrutiny by the State Pollution Control or the Pollution Control Committee concerned.

7. **Responsibilities of dismantler** – Every dismantler shall-

(1) obtain authorization and registration from the State Pollution Control Board in accordance with the procedure under the rules 9 and 11;

(2) ensure that no damage is caused to the environment during storage and transportation of e-waste;

(3) ensure that the dismantling processes do not have any adverse effect on the health and the environment;

(4) ensure that the facility and dismantling processes are in accordance with the standards or guidelines published by the Central Pollution Control Board from time to time;

(5) ensure that dismantled e-waste are segregated and sent to the registered recycling facilities for recovery of materials;

(6) ensure that non-recyclable/non- recoverable components are sent to authorized treatment storage and disposal facilities;

(7) file a return in Form 3, to the State Pollution Control Board or the Pollution Control Committee concerned as the case may be, on or before 30th June following the financial year to which that return relates;

(8) not process any e-waste for recovery or refining of materials, unless he is registered with State Pollution Control Board as a recycler for refining and recovery of materials.

8. **Responsibilities of recycler**– Every recycler shall-

(1) obtain authorization and registration from State Pollution Control Board in accordance with the procedure under the rules 9 and 11;

(2) ensure that the facility and recycling processes are in accordance with the standards laid down in the guidelines published by the Central Pollution Control Board from time to time;

(3) make available all records to the Central or State Pollution Control Board or Pollution Control Committee of Union territories for inspection;

(4) ensure that residue generated thereof is disposed of in a hazardous waste treatment storage disposal facility;

(5) file annual returns in Form 3, to the State Pollution Control Board or Pollution Control Committee concerned as the case may be, on or before 30th June following the financial year to which that returns relate.

CHAPTER III

PROCEDURE FOR SEEKING AUTHORIZATION AND REGISTRATION FOR HANDLING E-WASTES

9. **Procedure for grant of authorization.–**

(1) Every producer of electrical and electronic equipment listed in Schedule I, collection centre, dismantler and recycler of e-waste shall obtain an authorization from the State Pollution Control Board or Pollution Control Committee of Union territories concerned as the case may be.

(2) Every producer of electrical and electronic equipment listed in Schedule I, collection centre, dismantler and recycler of e-waste shall make an application, within a period of three months starting from the date of commencement of these rules in Form 1 to the State Pollution Control Board or the Pollution Control Committee for grant of authorization:

Provided that any person authorized under the provisions of the Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008, prior to the date of coming into force of these rules shall not be required to make an application for authorization till the period of expiry of such authorization:

Provided further that a recycler of e-waste who has not been authorized under the provisions of the Hazardous Waste (Management, Handling and Transboundary Movements) Rules, 2008, shall require auhtorization following the procedure mentioned in sub-rule (1) above.

(3) On receipt of the application complete in all respects for the authorization, the State Pollution Control Board or Pollution Control Committee of Union territories may, after such enquiry as it considers necessary and on being satisfied that the applicant possesses appropriate facilities, technical capabilities and equipment to handle e-waste safely, grant within a period of ninety days an authorization in Form-1(a) to the applicant to carry out safe operations in the authorized place only, which shall be valid for a period of five years.

(4) The State Pollution Control Board or Pollution Control Committee of the Union territories after giving reasonable opportunity of being heard to the applicant shall refuse to grant any authorization.

(5) Every person authorized under these rules shall maintain the record of e-waste handled by them in Form-2 and prepare and submit to the State Pollution Control Board or Pollution Control Committee, an annual return containing the details specified in Form 3 on or before 30th day of June following the financial year to which that return relates.

(6) An application for the renewal of an authorization shall be made in Form-1 before sixty days of its expiry and the State Pollution Control Board or Pollution Control Committee may renew the authorization after examining each case on merit and subject to the condition that there is no report of violation of the provisions of the Act or the rules made there under or the conditions specified in the authorization.

(7) Every producer of electrical and electronic equipment listed in Schedule I, collection centre, dismantler and recycler of e-waste shall take all steps, wherever required, to comply with the conditions specified in the authorization.

(8) The State Pollution Control Board in case of a respective State or the Pollution Control Committee in case of Union territories shall maintain a register containing particulars of the conditions imposed under these rules for environmentally sound management of e-waste, and it shall be open for inspection during office hours to any person interested or affected or a person authorized by him on his behalf.

10. **Power to suspend or cancel an authorization.-**

(1) The State Pollution Control Board or Pollution Control Committee of the Union territories may, if in its opinion, the holders of the authorization has failed to comply with any of the conditions of the authorization or with any provisions of the Act or these rules and after giving a reasonable opportunity of being heard and after recording reasons thereof in writing cancel or suspend the authorization issued under these rules for such period as it considers necessary in the public interest.

(2) Upon suspension or cancellation of the authorization, the State Pollution Control Board or Pollution Control Committee of the Union territories may give directions to the persons whose authorization has been suspended or cancelled for the safe storage of the e-waste and such person shall comply with such directions.

PROCEDURE FOR REGISTRATION WITH STATE POLLUTION CONTROL BOARD

11. **Procedure for grant of registration. –**

(1) Every dismantler or recycler of e-waste shall make an application, within a period of three months starting from the date of commencement of these rules, in Form-4 in triplicate to the State Pollution Control Board accompanied with a copy of the following documents for the grant or renewal of registration:-

(i) consent to establish granted by the State Pollution Control Board under Water (Prevention and Control of Pollution) Act, 1974, (25 of 1974) and Air (Prevention and Control of Pollution) Act, 1981(21 of 1981);

(ii) certificate of registration issued by the District Industries Centre or any other government agency authorized in this regard;

(iii) proof of installed capacity of plant and machinery issued by the District Industries Centre or any other government agency authorized in this behalf;

(iv) in case of renewal, a certificate of compliance of effluent and emission standards, treatment and disposal of hazardous wastes as applicable from the State Pollution Control Board or Committee of the Union territories or any other agency designated for this purpose;

Provided that any person registered under the provisions of the Hazardous Wastes (Management, Handling and Transboundary Movements) Rules, 2008, prior to the date of coming into force of these rules shall not be required to make an application for registration till the period of expiry of such registration:

Provided further that a recycler of e-waste who has not been registered under the provisions of the Hazardous Waste (management, Handling and Transboundary Movements) Rules, 2008, shall require registration following the procedure mentioned in sub-rule (1) of rule 11.

(2) The State Pollution Control Board, on being satisfied that the application is complete in all respects and that the applicant is utilizing environmentally sound technologies and possess adequate technical capabilities, requisite facilities and equipment to recycle and process e-waste, may grant registration to such applicants stipulating therein necessary conditions as deemed necessary for carrying out safe operations in the authorized place only.

(3) The State Pollution Control Board shall dispose of the application for registration within a period of ninety days from the date of the receipt of such application complete in all respects.

(4) The registration granted under these rules shall be valid initially for a period of two years and thereafter for a period of maximum five years on subsequent renewals from the date of its issue, unless the operation is discontinued by the unit or the registration suspended or cancelled by the State Pollution Control Board.

(5) The State Pollution Control Board may after giving reasonable opportunity of being heard to the applicant, by order, refuse to grant or renew.

(6) The State Pollution Control Board shall monitor the compliance of conditions stipulated for granting registration.

(7) The State Pollution Control Board may cancel or suspend a registration granted under these rules, if it has reasons to believe that the registered recycler has failed to comply with any of the conditions of registration, or with any provisions of the Act or rules made there under, after giving an opportunity to the recycler to be heard and after recording the reasons there for.

(8) An application for the renewal of registration shall be made in Form-4 before sixty days of its expiry and the State Pollution Control Board or Pollution Control.Committee may renew the registration after examining each case on merit and subject to the condition that there is no report of violation of the provisions of the Act or the rules made there under or the conditions specified in the registration.

(9) The dismantler or recycler shall maintain records of the e-waste purchased and processed and shall file annual returns of its activities of previous year in Form 3 to the State Pollution Control Board or Pollution Control Committee on or before 30th day of June of every year.

(10) The Central Government and the Central Pollution Control Board may issue guidelines for standards of performance for recycling processes from time to time.

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CHAPTER IV

12. **Procedure for storage of e-waste,-** Every producer, collection centre, dismantler or recyclers may store the e-waste for a period not exceeding one hundred and eighty days and shall maintain a record of collection, sale, transfer, storage and segregation of wastes and make these records available for inspection:

Provided that the State Pollution Control Board may extend the said period up to one year in the following cases, namely:

(i). Collection centers in the States, which do not have any registered dismantling or recycling facility; or Dismantlers in the States, which do not have any registered recycling facility;

(ii). the waste which needs to be specifically stored for development of a process for its recycling or reuse.

CHAPTER V

REDUCTION IN THE USE OF HAZARDOUS SUBSTANCES IN THE MANUFACTURE OF ELECTRICAL AND ELECTRONIC EQUIPMENT

13. **Reduction in the use of hazardous materials in the manufacture of electrical and electronic equipment.–**

(1) Every producer of electrical and electronic equipment listed in schedule I shall ensure that, new electrical and electronic equipment does not contain Lead, Mercury, Cadmium, Hexavalent Chromium, polybrominated biphenyls or polybrominated diphenyl ethers:

Provided that a maximum concentration value of 0.1% by weight in homogenous materials for lead, mercury, hexavalent chromium, polybrominated biphenyls and polybrominated diphenyl ethers and of 0.01% by weight in homogenous materials for cadmium shall be permitted.

(2) The applications listed in Schedule-II shall be exempted from provisions of sub-rule (1) of rule 13.

(3) The sub-rule(1) of rule 13 shall not apply to components of electrical and electronic equipment manufactured or placed in the market six years before the date of commencement of these rules.

(4) In the event of such reduction in the hazardous materials used in the electrical and electronic equipment, the detailed information on the constituents of the equipment shall be provided in the product information booklet.

(5) Imports or placement in the market for new electrical and electronic equipment shall be permitted only for those which are compliant to provisions of sub-rule (1) of rule 13.

(6) Manufacture and supply of electrical and electronic equipment used for defense and other similar strategic applications shall be excluded from provisions of sub-rule (1) of rule 13.

(7) Such reduction in use of hazardous substances in manufactured or imported electrical and electronic equipment shall be achieved within a period of two years from the date of commencement of these rules.

CHAPTER VI

MISCELLANEOUS

14. **Duties of Authorities.** - subject to other provisions of these rules, the authorities shall perform duties as specified in Schedule-III.

15. **Annual Report.-**

(1) The State Boards and the Committees shall prepare and submit to the Central Pollution Control Board an annual report with regard to the implementation of these rules by the 30^{th} September every year in Form 5.

(2) The Central Pollution Control Board shall prepare the consolidated annual review report on management of e-waste and forward it to the Central Government along with its recommendations before the 30^{th} December every year.

16. **Transportation of e-waste. –**

(1) In case of transportation of e-waste for final disposal to a facility in a State other than the State where the waste is generated/collected, the transporter shall obtain 'No Objection Certificate' from the State Pollution Control Board concerned and shall intimate the State Pollution Control Board of the State(s) of transit.

(2) In case of transportation of e-waste for dismantling or for recycling in a State other than the State where the waste is generated or collected, the transporter shall give prior intimation to the State Pollution Control Boards concerned and the State Pollution Control Boards of the State(s) of transit.

17. **Accident reporting and follow-up.-** where an accident occurs at the facility processing e-waste or during transportation of e-waste, the producer, transporter, dismantler, or recycler, as the case may be, shall report immediately to the State Pollution Control Boards or Committees of Union territories about the accident.

18. The collection, storage, transportation, segregation, refurbishment, dismantling, recycling and disposal of e-waste shall be in accordance with the procedures prescribed in the guidelines published by the Central Pollution Control Boards from time to time.

SCHEDULE I

(see rules 2 (1), 3(j) and (k))

Categories of electrical and electronic equipment covered under the rules

Sr. No.	Categories of electrical and electronic equipment
i.	**Information technology and telecommunication equipment :** Centralised data processing: Mainframes, Minicomputers Personal computing: Personal Computers (Central Processing Unit with input and output devices) Laptop Computers(Central Processing Unit with input and output devices) Notebook Computers Notepad Computers Printers including cartridges Copying equipment Electrical and electronic typewriters User terminals and systems Facsimile Telex Telephones Pay telephones Cordless telephones Cellular telephones Answering systems
ii.	**Consumer electrical and electronics:** Television sets (including sets based on (Liquid Crystal Display and Light Emitting Diode technology), Refrigerator, Washing Machine, Air-conditioners excluding centralised air conditioning plants

SCHEDULE II

[See rule 13(2)]

Applications, which are exempted from the requirements of sub-rule (1) of rule 13 (applicable to categories of electrical and electronic equipment as listed in Schedule I)

	Exemption
1	Mercury in single capped (compact) fluorescent lamps not exceeding (per burner):
1(a)	For general lighting purposes < 30 W:5 mg
1(b)	For general lighting purposes ≥ 30 W and < 50 W:5 mg
1(c)	For general lighting purposes ≥ 50 W and < 150 W:5 mg
1(d)	For general lighting purposes ≥ 150 W:15 mg
1(e)	For general lighting purposes with circular or square structural shape and tube diameter ≤ 17 mm: 7mg
1(f)	For special purposes: 5 mg
2(a)	Mercury in double-capped linear fluorescent lamps for general lighting purposes

	not exceeding (per lamp):
2(a)(1)	Tri-band phosphor with normal lifetime and a tube diameter > 9 mm (e.g. T2): 4 mg
2(a)(2)	Tri-band phosphor with normal lifetime and a tube diameter ≥ 9 mm and ≥ 17 mm (e.g. T5): 3 mg
2(a)(3)	Tri-band phosphor with normal lifetime and a tube diameter > 17 mm and ≤ 28 mm (e.g. T8): 3.5 mg
2(a)(4)	Tri-band phosphor with normal lifetime and a tube diameter > 28 mm (e.g. T12): 5 mg
2(a)(5)	Tri-band phosphor with long lifetime (≥ 25000 h): 8 mg
2(b)	Mercury in other fluorescent lamps not exceeding (per lamp):
2(b)(1)	Linear halophosphalte lamps with tube > 28 mm (e.g T 10 and T12): 10 mg
2(b)(2)	Non- linear halophosphate lamps (all diameters): 15 mg
2(b)(3)	Non- linear tri-band phosphor lamps with tube diameter > 17 mm (e.g. T9):15 mg
2(b)(4)	Lamps for other general lighting and special purposes (e.g. induction lamps): 15mg
3	Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for special purposes not exceeding (per lamp):
3(a)	Short length (≤ 500 mm): 3.5mg
3(b)	Medium length (> 500 mm and ≤ 1500 mm): 5mg
3(c)	Long length (> 1500 mm): 13mg
4(a)	Mercury in other low pressure discharge lamps (per lamp)
4(b)	Mercury in High Pressure Sodium (vapour) lamps for general lighting purposes not exceeding (per burner) in lamps with improved colour rendering index Ra>60:
4(b)-I	P ≤ 155 W: 30mg
4(b)-II	155 W < P ≤ 405 W: 40mg
4(b)-III	P > 405 W: 40mg
4(c)	Mercury in other High Pressure Sodium (vapour) lamps for general lighting purposes not exceeding (per burner):
4(c)-I	P ≤ 155 W: 25mg
4(c)- II	155 W <P≤ 405 W: 30mg
4(c)-III	P> 405 W: 40mg
4(d)	Mercury in High Pressure Mercury (vapour) lamps (HPMV)
4(e)	Mercury in metal halide lamps (MH)
4(f)	Mercury in other discharge lamps for special purposes not specifically mentioned in this Schedule
5(a)	Lead in glass of cathode ray tubes
5(b)	Lead in glass of fluorescent tubes not exceeding 0.2 % by weight
6(a)	Lead as an alloying element in steel for machining purposes and in galvanized steel containing up to 0.35% lead by weight
6(b)	Lead as an alloying element in aluminum containing up to 0.4%lead by weight
6(c)	Copper alloy containing up to 4% lead by weight
7 (a)	Lead in high melting temperature type solders (i.e. lead-based alloys containing 85% by weight or more lead)
7(b)	Lead in solders for servers, storage and storage array systems, network infrastructure equipment for switching, signaling, transmission, and network management for telecommunications
7(c)- I	Electrical and electronic components containing lead in a glass or ceramic other than dielectric ceramic in capacitors, e.g. piezoelectronic devices, or in a glass or ceramic matrix compound.
7(c)-II	Lead in dielectric ceramic in capacitors for a rated voltage of 125 V AC or 250 V DC or higher

7(c)-III	Lead in dielectric ceramic in capacitors for a rated voltage of 125 V AC or 250 V DC
8(a)	Cadmium and its compounds in one shot pellet type thermal cut-offs.
8(b)	Cadmium and its compounds in electrical contacts
9	Hexavalent chromium as an anticorrosion agent of the carbon steel cooling system in absorption refrigerators up to 0,75 % by weight in the cooling solution
9(b)	Lead in bearing shells and bushes for refrigerant-containing compressors for heating, ventilation, air conditioning and refrigeration (HVACR) application.
11(a)	Lead used in C-press complaining pin connector systems
11(b)	Lead used in other than C-press complaint pin connector systems
12	Lead as a coating material for the thermal conduction module C-ring
13(a)	Lead in while glasses used for optical applications
13(b)	Cadmium and lead in filter glasses and glasses used for reflectance standards.
14	Lead in solders consisting of more than two elements for the connection between the pins and the package of microprocessors with a lead content of more than 80% and less than 85% by weight
15	Lead in solders to complete a viable electrical connection between semiconductor die and carrier within integrated circuit flip chip packages.
16	Lead in linear incandescent lamps with silicate coated tubes
17	Lead halide as radiant agent in high intensity discharge (HID) lamps used for professional reprography applications.
18(a)	Lead as activator in the fluorescent powder (1 % lead by weight or less) of discharge lamps when used as specialty lamps for diazoprinting reprography, lithography, insect traps, photochemical and curing processes containing phosphors such as SMS ((Sr, Ba)2MgSi2O7:Pb)
18(b)	Lead as activator in the fluorescent powder (1 % lead by weight or less) of discharge lamps when used as sun tanning lamps containing phosphors such as BSP (BaSi2O5:Pb)
19	Lead with PbBiSn-Hg and PbInSn-Hg in specific compositions as main amalgam and with PbSn-Hg as auxiliary amalgam in very compact energy saving lamps (ESL)
20	Lead oxide in glass used for bonding front and rear substrates of flat fluorescent lamps used for Liquid Crystal Displays (LCDs)
21	Lead and cadmium in printing inks for the application of enamels on glasses, such as borosilicate and soda lime glasses
23	Lead in finishes of fine pitch components other than connectors with a pitch of 0.65 mm and less
24	Lead in solders for the soldering to machined through hole discoidal an planar array ceramic multilayer capacitors
25	Lead oxide in surface conduction electron emitter displays (SED) used in structural elements, notably in the seal frit and frit ring.
26	Lead oxide in the glass envelope of black light blue lamps
27	Lead alloys as solder for transducers used in high- powered (designated to operate for several hours at acoustic power levels of 125 dB SPL and above) loudspeakers
29	Lead bound in crystal glass
30	Cadmium alloys as electrical/mechanical solder joints to electrical conductors located directly on the voice coil in transducers used in high-powered loudspeakers with sound pressure levels of 100 dB (A) and more
31	Lead in soldering materials in mercury free flat fluorescent lamps(which e.g. are used for liquid crystal displays, design or industrial lighting)
32	Lead oxide in seal frit used for making window assemblies for Argon and Krypton laser tubes

33	Lead in solders for the soldering of thin copper wires of 100 μm diameter and less in power transformers
34	Lead in cermet-based trimmer potentiometer elements
36	Mercury used as a cathode sputtering inhibitor in DC plasma displays with a content up to 30 mg per display
37	Lead in the plating layer of high voltage diodes on the basis of a zinc borate glass body
38	Cadmium and cadmium oxide in thick film pastes used on aluminum bonded beryllium oxide
39	Cadmium in colour converting II-VI LEDs (< 10 μg Cd per mm^2 of light-emitting area) for use in solid state illumination or display systems.

SCHEDULE III

[See rule 14)]

LIST OF AUTHORITIES AND CORREPONDING DUTIES

SI No	AUTHORITY	CORRESPONDING DUTIES
1.	Central Pollution Control Board, Delhi	(i) Coordination with State Pollution Control Boards/ Committees of Union territories (ii) Preparation of Guidelines for Environmentally Sound Management of e-waste (iii) Conduct assessment of e-waste generation and processing (iv) Recommend standards and specifications for processing and recycling e-waste (v) Documentation, compilation of data on e-waste and uploading on websites of Central Pollution Control Board (vi) Conducting training & awareness programmes (vii) Submit Annual Report to the Ministry (viii) Any other function delegated by the Ministry under these rules (ix) Enforcement of provisions regarding reduction in use of hazardous substances in manufacture of electrical and electronic equipment (x) Initiatives for IT industry for reducing hazardous substances, (xi) Set targets for compliance to the reduction in use of hazardous substance in manufacture of electrical and electronic equipment (xii) Incentives and certification for green design/products
2.	State Pollution Control Boards/ Committees of Union territories	(i) Inventorization of e-waste. (ii) Grant & renewal of Authorization (iii) Registration of recyclers of e-waste (iv) Monitoring compliance of authorization and registration conditions (v) Maintain information on the conditions imposed for authorization etc. (vi) Implementation of programmes to encourage environmentally sound recycling (vii) Action against violations of these rules (viii) Any other function delegated by the Ministry under these rules

3.	Urban Local Bodies (Municipal Committee/Council/ Corporation)	(i) To ensure that e-waste if found to be mixed with Municipal Solid Waste is properly segregated, collected and is channelized to either authorized collection centre or dismantler or recycler. (ii) To ensure that e-waste pertaining to orphan products is collected and channelized to either authorized collection centre or dismantler or recycler.

FORM – 1

[See rule 9(2)]

APPLICATION FOR OBTAINING AUTHORIZATION FOR GENERATION/ COLLECTION/ STORAGE/DISMANTLING/RECYCLING/ OF E-WASTE*

From: ....

....

To

The Member Secretary,

.... Pollution Control Board or................. Pollution Control Committee

....

....

Sir,

I / We hereby apply for authorization/renewal of authorization under rule 11(2) and 11(6) of the E-wastes (Management and Handling) Rules, 2011 for collection/ storage/ transport/treatment/disposal of e-wastes.

For Office Use Only

Code No. :

Whether the unit is situated in a critically polluted area as identified by Ministry of Environment and Forests (yes/no);

To be filled in by Applicant

Part – A: General

1. (a) Name and full address, telephone nos. e-mail and other contact details of the unit :
   (b) Authorization required for (Please tick mark appropriate activity/ies*)
   (i) Generation* ☐
   (ii) Collection* ☐
   (iii) Dismantling* ☐
   (iv) Recycling* ☐
   (c) In case of renewal of authorization previous authorization no. and date
2. (a) Whether the unit is generating or processing e-waste as defined in the E-wastes (Management and Handling) Rules, 2011
   :
   (i) generating* ☐
   (ii) processing* ☐

*strike off whichever is not applicable

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3. (a) Total capital invested on the project :
   (b) Year of commencement of production:
   (c) Date of grant of the Consent to Establish:
   (d) Date of grant of the Consent to Operate:

Part – B: e-waste

4. E-waste details:

(a)	Type of e-wastes generated as defined under the e-wastes (Management and Handling) Rules, 2011:	
(b)	Total Quantity e-waste handled generated/collected/dismantled/ recycled :	
(c)	Mode of storage within the plant :	
(d)	Method of treatment and disposal :	
(e)	Installed capacity of the plant :	

Part – C : Dismantling and Recycling Facility

5. Detailed proposal of the facility (to be attached) to include:
   (i) Location of site (provide map).
   (ii) Details of processing technology
   (i) Type and Quantity of waste to be processed per day
   (iv) Site clearance (from local authority, if any)
   (v) Utilization of the e-waste processed
   (vi) Method of disposal of residues (details to be given)
   (vii) Quantity of waste to be processed or disposed per day
   (viii) Details of categories of e-waste to be dismantled/processed
   (ix) Methodology and operational details
   (x) Measures to be taken for prevention and control of environmental pollution including treatment of leachates
   (xii) Investment on Project and expected returns
   (xiii) Measures to be taken for safety of workers working in the plant

Place : __________ Signature ______________

(Name________________)

Date : __________ Designation : ___________

FORM 1(a)

[*See rule 9(3)*]

FORM FOR GRANTING AUTHORIZATION FOR GENERATION/COLLECTION/ /STORAGE/DISMANTLING/ RECYCLING/ OF E-WASTE*

1. (a) Authorization and (b) date of issue ....

2. ....of.................................is hereby granted an authorization for generation, collection, storage, dismantling and recycling of e-waste on the premises situated at...

3. The authorization granted for generation, collection, storage, dismantling, and recycling of e-wastes.

4. The authorization shall be in force for a period from ....to ....

5. The authorization is subject to the conditions stated below and such conditions as may be specified in the rules for the time being in force under the Environment (Protection) Act, 1986.

Signature-------------------------
Designation --------------------- Date: ----------------------

Terms and conditions of authorization

1. The authorization shall comply with the provisions of the Environment (Protection) Act, 1986, and the rules made there under.
2. The authorization or its renewal shall be produced for inspection at the request of an officer authorized by the State Pollution Control Board or Committee of Union territories.
3. The person authorized shall not rent, lend, sell, transfer or otherwise transport the e-wastes without obtaining prior permission of the State Pollution Control Board or Committee of Union territories.
4. Any unauthorized change in personnel, equipment as working conditions as mentioned in the application by the person authorized shall constitute a breach of his authorization.
5. It is the duty of the authorized person to take prior permission of the State Pollution Control Board or Committee of Union territories to close down the operations.
6. An application for the renewal of an authorization shall be made as laid down in sub-rule (6) of rule 9.

FORM – 2

[See rules 4(8), 5(5) and 9(5)]

FORM FOR MAINTAINING RECORDS OF E-WASTE HANDLED/ GENERATED

Quantity in Metric Tonnes (MT) or Kilograms (Kg) per year

1.	Name & Address: Producer /Collection Centre/Dismantler/ Recycler/ Bulk consumer *		
2.	Date of Issue of Authorization* Registration *		
3.	Validity of Authorization* /Registration*		
4.	Types & Quantity of e-waste handled/ generated	Category	Quantity
		Item Description	
5.	Types & Quantity of e-waste stored	Category	Quantity
		Item Description	
6.	Types & Quantity of e-waste sent to authorized collection centre/ registered dismantler or recycler	Category	Quantity
		Item Description	
7.	Types & Quantity of e-waste transported*	Category	Quantity
		Quantity	
	Name, address and contact details of the destination		
8.	Types & Quantity of e-waste refurbished*	Category	Quantity
		Item Description	
	Name, address and contact details of the destination of refurbished materials		
9.	Types & Quantity of e-waste dismantled*	Category	Quantity
		Item Description	
	Name, address and contact details of the destination		
10.	Types & Quantity of e-waste recycled*	Category	Quantity
	Types & Quantity of materials recovered	Item Description	
		Quantity	
	Name, address and contact details of the destination		
11.	Types & Quantity of waste treated & disposed	Category	Quantity
		Item Description	

* Strike off whichever is not applicable

FORM – 3

[See rules 4(9), 5(4), 6(2), 7(7), 8(5) and 9(5)]

FORM FOR FILING ANNUAL RETURNS

[To be submitted by producer/collection centre/dismantler/recycler by 30th June following to the financial year to which that return relates].

Quantity in Metric Tonnes (MT) or Kilograms (Kg) per year

1	Name and address of the producer/ collection centre/ dismantler/ recycler		
2	Name of the authorized person and complete address with telephone and fax numbers and e-mail address		
3	Total quantity e-waste sold/purchased/ sent for processing during the year for each category of electrical and electronic equipment listed in the Schedule I (Attach list)		
	Details of the above	TYPE	QUANTITY
3(A)*	**DISMANTLERS**: Quantity of e-waste in MT purchased & processed and sent to (category wise):		
3(B)*	**RECYCLERS**: Quantity of e-waste in MT purchased/processed (category wise):		
4	Name and full address of the destination with respect to 3 (A-B) above		
5	Type and quantity of materials segregated/ recovered from e-waste of different categories as applicable to 3(A) &3(B)	Type	Quantity

Note: The applicant shall provide details of funds received (if any) from producers and its utility with an audited certificate

✓ enclose the list of recyclers to whom e-waste have been sent for recycling.

*strike off whichever is not applicable

Place__________________

Date__________________

Signature of the authorized person

FORM - 4

[see rule 11(1)]

APPLICATION FORM FOR REGISTRATION OF FACILITIES POSSESSING ENVIRONMENTALLY SOUND MANAGEMENT PRACTICE FOR RECYCLING E-WASTE

(To be submitted in triplicate)

<table>
<tr><td>1.</td><td>Name and Address of the unit</td><td colspan="3"></td></tr>
<tr><td>2.</td><td>Contact person with designation, Tel./Fax</td><td colspan="3"></td></tr>
<tr><td>3.</td><td>Date of Commissioning</td><td colspan="3"></td></tr>
<tr><td>4.</td><td>No. of workers (including contract labour)</td><td colspan="3"></td></tr>
<tr><td>5.</td><td>Consents Validity</td><td colspan="3">a. Water (Prevention & Control of Pollution) Act, 1974;
Valid up to ________________
b. Air (Prevention & Control of Pollution) Act, 1981;
Valid up to________________</td></tr>
<tr><td>6.</td><td>Authorization validity</td><td colspan="3">E-wastes (Management and Handling) Rules, 2011;
Valid up to ____________</td></tr>
<tr><td>7.</td><td>Manufacturing Process</td><td colspan="3">Please attach manufacturing process flow diagram for each product(s)</td></tr>
<tr><td rowspan="3">8.</td><td rowspan="3">Products and Installed capacity of production in (MTA)</td><td colspan="2">Products</td><td>Installed capacity (MTA)</td></tr>
<tr><td colspan="2"></td><td></td></tr>
<tr><td colspan="2"></td><td></td></tr>
<tr><td rowspan="3">9.</td><td rowspan="3">Products manufactured during the last three years (as applicable)</td><td>Year</td><td>Product</td><td>Quantity</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td rowspan="3">10.</td><td rowspan="3">Raw material consumption during the last three years (as applicable)</td><td>Year</td><td>Product</td><td>Quantity</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td rowspan="5">11.</td><td>Water consumption</td><td colspan="3">Industrial ____________m3/day
Domestic____________m3 / day</td></tr>
<tr><td>Water Cess paid up to (if applicable)</td><td colspan="3"></td></tr>
<tr><td>Waste water generation as per consent ______________m3/day</td><td colspan="3">Actual (avg., of last 3 months)
Industrial ____________m3 /day
Domestic ____________m3 /day</td></tr>
<tr><td>Waste water treatment (provide flow diagram of the treatment scheme)</td><td colspan="3">Industrial
Domestic</td></tr>
<tr><td>Waste water discharge</td><td colspan="3">Quantity ____________m3/day
Location ____________________
Analysis of treated waste water for pH, BOD,COD, SS, O&G, any other</td></tr>
</table>

<table>
<tr><td></td><td></td><td colspan="4">parameter stipulated by SPCB/SPCC (attach details)</td></tr>
<tr><td>12.</td><td>Air Pollution Control</td><td colspan="4"></td></tr>
<tr><td></td><td>a. Provide flow diagram for emission control system(s) installed for each process unit, utilities etc.</td><td colspan="4"></td></tr>
<tr><td></td><td>b. Details for facilities provided for control of fugitive emission due to material handling, process, utilities etc</td><td colspan="4"></td></tr>
<tr><td></td><td rowspan="3">c. Fuel consumption</td><td colspan="2">Fuel</td><td colspan="2">Qty per day/month</td></tr>
<tr><td></td><td colspan="2">(i)</td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2">(ii)</td><td colspan="2"></td></tr>
<tr><td></td><td rowspan="3">d. Stack emission monitoring</td><td colspan="2">Stack attached to</td><td colspan="2">Emission (SPM, SO_2, NOx , Pb etc.) mg/Nm^3</td></tr>
<tr><td></td><td colspan="2">(i)</td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2">(ii)</td><td colspan="2"></td></tr>
<tr><td></td><td rowspan="3">e. Ambient air quality</td><td colspan="2">Location Results ug/m3</td><td colspan="2">Parameters SPM, SO_2, NOx, Pb etc.) µg/m^3</td></tr>
<tr><td></td><td colspan="2">(i)</td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2">(II)</td><td colspan="2"></td></tr>
<tr><td>13.</td><td>Waste Management:</td><td colspan="4"></td></tr>
<tr><td></td><td rowspan="4">a. Waste generation in processing e-waste</td><td>S No</td><td>Type</td><td>Category</td><td>Qty</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>b. Waste Collection and transportation (attach details)</td><td colspan="4"></td></tr>
<tr><td></td><td rowspan="4">c. Provide details of disposal of residue.</td><td>S No</td><td>Type</td><td>Category</td><td>Qty</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>d. Name of Treatment Storage and Disposal Facility utilized for</td><td colspan="4"></td></tr>
<tr><td></td><td>e. Please attach analysis report of characterization of hazardous waste generated (including leachate test if applicable)</td><td colspan="4"></td></tr>
<tr><td>14.</td><td>Details of e-waste proposed to be procured through sale, contract or import, as the case may be, for use as raw material</td><td colspan="4">(i) Name
(ii) Quantity required /year
(iii) Basel Convention Number</td></tr>
<tr><td>15.</td><td>Occupational safety and health aspects</td><td colspan="4">Please provide details of facilities</td></tr>
</table>

16.	Remarks:	
	Whether industry has provided adequate pollution control system / equipment to meet the standards of emission / effluent.	Yes/No If Yes, please furnish details
	Whether industry is in compliance with conditions laid down in the Authorization	Yes / No
17.	Any Other Information of relevance: i) ii)	

I hereby declare that the above statements /information are true and correct to the best of my knowledge and belief.

Signature

Date:______________ Name:______________________

Place:______________ Designation:______________________

Form - 5

[see rule 15 (1)]

FORM FOR ANNUAL REPORT TO BE SUBMITTED BY THE STATE POLLUTION CONTROL BOARD/COMMITTEES TO THE CENTRAL POLLUTION CONTROL BOARD

To,

The Chairman,
Central Pollution Control Board,
(Ministry of Environment And Forests)
Government Of India,
'Parivesh Bhawan', East Arjun Nagar,
Delhi- 110 0032

1. Name of the State/Union territory :
2. Name & address of the State Pollution Control Board / Committee :
3. Number of authorised Producers, Collection Centres, registered Dismantler and Recyclers for management of e-waste in the State or Union territory under these rules :
4. Categories of waste collected along with their quantities on a monthly average basis: : Please attach as Annexure-I

5. A Summary Statement on Category wise and product wise quantity of e-waste collected : Please attach as Annexure-II
6. Mode of treatment with details : Please attach as Annexure-III
7. Brief details of collection, dismantling and recycling facilities : Please attach as Annexure-IV
8. Any other information :

9. Certified that the above report is for the period from ....
....

Date: ________________
Place : ________________

Chairman or the Member Secretary
State Pollution Control Board/
Pollution Control Committee

[F. No. 23-71/2009-HSMD]

RAJIV GAUBA, Jt. Secy.

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and Published by the Controller of Publications, Delhi-110054.

Appendix 7: E-Waste Management and Handling Rules 2016

[PUBLISHED IN THE GAZETTE OF INDIA, EXTRAORDINARY PART-II, SECTION3, SUB-SECTION (i)]

GOVERNMENT OF INDIA MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE

NOTIFICATION

New Delhi, the 23rd March, 2016

G.S.R 338(E). - Whereas the draft rules, namely the e-waste (Management) Rules,

2015, were published by the Government of India in the Ministry of Environment, Forest and Climate Change *vide* number G.S.R. 472(E), dated the 10th June, 2015 in the Gazette of India, Extraordinary Part II, section 3, sub-section (ii) inviting objections and suggestions from all persons likely to be affected thereby, before the expiry of the period of sixty days from the date on which copies of the Gazette containing the said notification were made available to the public;

AND WHEREAS the copies of the Gazette containing the said notification were made available to the public on the 10th day of June, 2015;

AND WHEREAS the objections and suggestions received within the specified period from the public in respect of the said draft rules have been duly considered by the Central Government;

NOW, THEREFORE, in exercise of the powers conferred by sections 6, 8 and 25 of the Environment (Protection) Act, 1986 (29 of 1986), and in supersession of the ewaste (Management and Handling) Rules, 2011, published in the Gazette of India, section 3, sub-section (ii), *vide* number S.O. 1035(E), dated the 12th May, 2011, except as respects things done or omitted to be done before such supersession, the Central Government hereby makes the following rules, namely:-

CHAPTER I

PRELIMINARY

1. Short title and commencement. - (1) These rules may be called the E-Waste (Management) Rules, 2016.

(2) They shall come into force from the 1st day of October, 2016.

2. Application. - These rules shall apply to every manufacturer, producer, consumer, bulk consumer, collection centres, dealers, e-retailer, refurbisher**,** dismantler and recycler involved in manufacture, sale, transfer, purchase, collection, storage and processing of e-waste or electrical and electronic equipment listed in Schedule I, including their components, consumables, parts and spares which make the product operational but shall not apply to -

(a) used lead acid batteries as covered under the Batteries (Management and Handling) Rules, 2001 made under the Act;
(b) micro enterprises as defined in the Micro, Small and Medium Enterprises Development Act, 2006 (27 of 2006); and
(c) radio-active wastes as covered under the provisions of the Atomic Energy Act, 1962 (33 of 1962) and rules made there under.

3. Definitions. - (1) In these rules, unless the context otherwise requires, -

(a) 'Act' means the Environment (Protection) Act, 1986 (29 of 1986);
(b) 'authorisation' means permission for generation, handling, collection, reception, storage, transportation, refurbishing, dismantling, recycling, treatment and disposal of e-waste, granted to manufacturer, dismantler, refurbisher and recycler;
(c) 'bulk consumer' means bulk users of electrical and electronic equipment such as Central Government or State Government Departments, public sector undertakings, banks, educational institutions, multinational organisations, international agencies, partnership and public or private companies that are registered under the Factories Act, 1948 (63 of 1948) and the Companies Act, 2013 (18 of 2013) and health care facilities which have turnover of more than one crore or have more than twenty employees;
(d) 'Central Pollution Control Board' means the Central Pollution Control Board constituted under sub-section (1) of section 3 of the Water (Prevention and Control of Pollution) Act, 1974 (6 of 1974);
(e) 'collection centre' means a centre or a collection point or both established by producer individually or as association jointly to collect e-waste for channelising the e-waste to recycler and play such role as indicated in the authorisation for Extended Producer Responsibility granted to the producer and having facilities as per the guidelines of Central Pollution Control Board, including the collection centre established by the dismantler or refurbisher or recycler which should be a part of their authorisation issued by the State Pollution Control Board where the facility exists;
(f) ‘component’ means one of the parts of a sub-assembly or assembly of which a manufactured product is made up and into which it may be resolved and includes an accessory or attachment to another component;
(g) ‘consumables’ means an item, which participates in or is required for a manufacturing process or for functioning of the electrical and electronic equipment and may or may not form part of end-product. Items, which are

substantially or totally consumed during a manufacturing process, shall be deemed to be consumables;

(h) 'consumer' means any person using electrical and electronic equipment excluding the bulk consumers;

(i) ‘channelisation’ means to direct the path for movement of e-wastes from collection onwards to authorised dismantler or recycler. In case of fluorescent and other mercury containing lamps, where recyclers are not available, this means path for movement from collection centre to Treatment, Storage and Disposal Facility;

(j) 'dealer' means any individual or firm that buys or receives electrical and electronic equipment as listed in Schedule I of these rules and their components or consumables or parts or spares from producers for sale;

(k) ‘deposit refund scheme’ means a scheme whereby the producer charges an additional amount as a deposit at the time of sale of the electrical and electronic equipment and returns it to the consumer along with interest when the end-oflife electrical and electronic equipment is returned;

(l) 'dismantler' means any person or organisation engaged in dismantling of used electrical and electronic equipment into their components and having facilities as per the guidelines of Central Pollution Control Board and having authorisation from concerned State Pollution Control Board;

(m)'disposal' means any operation which does not lead to recycling, recovery or reuse and includes physico-chemical or biological treatment, incineration and deposition in secured landfill;

(n) ‘end-of-life’ of the product means the time when the product is intended to be discarded by the user;

(o) 'environmentally sound management of e-waste' means taking all steps required to ensure that e-waste is managed in a manner which shall protect health and environment against any adverse effects, which may result from such e-waste;

(p) 'electrical and electronic equipment' means equipment which are dependent on electric current or electro-magnetic field in order to become functional;

(q) ‘e-retailer’ means an individual or company or business entity that uses an electronic network such as internet, telephone, to sell its goods;

(r) 'e-waste' means electrical and electronic equipment**,** whole or in part discarded as waste by the consumer or bulk consumer as well as rejects from manufacturing, refurbishment and repair processes;

(s) ‘e-waste exchange’ means an independent market instrument offering assistance or independent electronic systems offering services for sale and purchase of e-waste generated from end-of-life electrical and electronic equipment between agencies or organisations authorised under these rules;

(t) ‘Extended Producer Responsibility’ means responsibility of any producer of electrical or electronic equipment, for channelisation of e-waste to ensure environmentally sound management of such waste. Extended Producer Responsibility may comprise of implementing take back system or setting up of collection centres or both and having agreed arrangements with authorised dismantler or recycler either individually or collectively through a

Producer Responsibility Organisation recognised by producer or producers in their Extended Producer Responsibility - Authorisation;

(u) 'Extended Producer Responsibility - Authorisation' means a permission given by Central Pollution Control Board to a producer, for managing Extended Producer Responsibility with implementation plans and targets outlined in such authorisation including detail of Producer Responsibility Organisation and e-waste exchange, if applicable;

(v) 'Extended Producer Responsibility Plan' means a plan submitted by a producer to Central Pollution Control Board, at the time of applying for Extended Producer Responsibility - Authorisation in which a producer shall provide details of e-waste channelisation system for targeted collection including detail of Producer Responsibility Organisation and e-waste exchange, if applicable;

(w) 'facility' means any location wherein the process incidental to the collection, reception, storage, segregation, refurbishing, dismantling, recycling, treatment and disposal of e-waste are carried out;

(x) 'Form' means a form appended to these rules;

(y) 'historical e-waste' means e-waste generated from electrical and electronic equipment as specified in Schedule I, which was available on the date from which these rules come into force;

(z) 'manufacturer' means a person or an entity or a company as defined in the Companies Act, 2013 (18 of 2013) or a factory as defined in the Factories Act, 1948 (63 of 1948) or Small and Medium Enterprises as defined in Micro, Small and Medium Enterprises Development Act, 2006 (27 of 2006), which has facilities for manufacture of electrical and electronic equipment;

(aa) 'orphaned products' means non-branded or assembled electrical and electronic equipment as specified in Schedule I or those produced by a company, which has closed its operations;

(bb) 'part' means an element of a sub-assembly or assembly not normally useful by itself, and not amenable to further disassembly for maintenance purposes. A part may be a component, spare or an accessory;

(cc) 'producer' means any person who, irrespective of the selling technique used such as dealer, retailer, e-retailer, etc.;

   (i) manufactures and offers to sell electrical and electronic equipment and their components or consumables or parts or spares under its own brand; or

   (ii) offers to sell under its own brand, assembled electrical and electronic equipment and their components or consumables or parts or spares produced by other manufacturers or suppliers; or

   (iii) offers to sell imported electrical and electronic equipment and their components or consumables or parts or spares;

(dd) 'Producer Responsibility Organisation' means a professional organisation authorised or financed collectively or individually by producers, which can take the responsibility for collection and channelisation of e-waste generated from the 'end-of-life' of their products to ensure environmentally sound management of such e-waste;

(ee) 'recycler' - means any person who is engaged in recycling and reprocessing of waste electrical and electronic equipment or assemblies or their

components and having facilities as elaborated in the guidelines of Central Pollution Control Board;

(ff) 'refurbishment' means repairing of used electrical and electronic equipment as listed in Schedule I for extending its working life for its originally intended use and selling the same in the market or returning to owner;

(gg) 'refurbisher' for the purpose of these rules, means any company or undertaking registered under the Factories Act, 1948 or the Companies Act, 1956 or both or district industries centre engaged in refurbishment of used electrical and electronic equipment;

(hh) 'Schedule' means the Schedule appended to these rules;

(ii) "spares" means a part or a sub-assembly or assembly for substitution which is ready to replace an identical or similar part or sub-assembly or assembly including a component or an accessory;

(jj) 'State Government in relation to an Union territory means, the Administrator thereof appointed under article 239 of the Constitution;

(kk) 'State Pollution Control Board' means the concerned State Pollution Control Board or the Pollution Control Committee of the Union Territories constituted under sub-section (1) of section 4 of the Water (Prevention and Control of Pollution) Act, 1974 (6 of 1974);

(ll) 'target' means the quantity of e-waste to be collected by the producer in fulfilment of Extended Producer Responsibility;

(mm) 'transporter' means a person or company or entity engaged in the off-site transportation of e-waste by air, rail, road or water carrying a manifest system issued by the person or company or entity who has handed over the e-waste to the transporter, giving the origin, destination and quantity of the e-waste being transported;

(2) Words and expressions used in these rules and not defined but defined in the Act shall have the meanings respectively assigned to them in the Act.

CHAPTER II

RESPONSIBILITIES

4. **Responsibilities of the manufacturer.** - (1) collect e-waste generated during the manufacture of any electrical and electronic equipment and channelise it for recycling or disposal;

(2) apply for an authorisation in Form 1 (a) in accordance with the procedure prescribed under sub-rule (2) of rule 13 from the concerned State Pollution Control Board, which shall give the authorisation in accordance with Form 1 (bb);

(3) ensure that no damage is caused to the environment during storage and transportation of e-waste;

(4) maintain records of the e-waste generated, handled and disposed in Form-2 and make such records available for scrutiny by the concerned State Pollution Control Board;

(5) file annual returns in Form-3, to the concerned State Pollution Control Board on or before the 30th day of June following the financial year to which that return relates.

5. Responsibilities of the producer. - The producer of electrical and electronic equipment listed in Schedule I shall be responsible for -

(1) implementing the Extended Producers Responsibility with the following frameworks, namely:-

(a) collection and channelisation of e-waste generated from the 'end-of-life' of their products or 'end-of-life' products with same electrical and electronic equipment code and historical waste available on the date from which these rules come into force as per Schedule I in line with the targets prescribed in Schedule III in Extended Producer Responsibility - Authorisation;

(b) the mechanism used for channelisation of e-waste from 'end-of-life' products including those from their service centres to authorised dismantler or recycler shall be in accordance with the Extended Producer Responsibility - Authorisation. In cases of fluorescent and other mercury containing lamps, where recyclers are not available, channelisation may be from collection centre to Treatment, Storage and Disposal Facility;

(c) for disposal in Treatment, Storage and Disposal Facility, a pre-treatment is necessary to immobilise the mercury and reduce the volume of waste to be disposed off;

(d) Extended Producer Responsibility - Authorisation should comprise of general scheme for collection of waste Electrical and Electronic Equipment from the Electrical and Electronic Equipment placed on the market earlier, such as through dealer, collection centres, Producer Responsibility Organisation, through buy-back arrangement, exchange scheme, Deposit Refund System, etc. whether directly or through any authorised agency and channelising the items so collected to authorised recyclers;

(e) providing contact details such as address, e-mail address, toll-free telephone numbers or helpline numbers to consumer(s) or bulk consumer(s) through their website and product user documentation so as to facilitate return of end-of-life electrical and electronic equipment;

(f) creating awareness through media, publications, advertisements, posters, or by any other means of communication and product user documentation accompanying the equipment, with regard to -

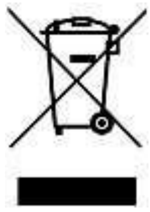
   (i) information on address, e-mail address, toll-free telephone numbers or helpline numbers and web site;

   (ii) information on hazardous constituents as specified in sub-rule 1 of rule 16 in electrical and electronic equipment;

   (iii) information on hazards of improper handling, disposal, accidental breakage, damage or improper recycling of e-waste;

   (iv) instructions for handling and disposal of the equipment after its use, along with the Do's and Don'ts;

(v) affixing a visible, legible and indelible symbol given below on the products or product user documentation to prevent e-waste from being dropped in garbage bins containing waste destined for disposal;



(vi) means and mechanism available for their consumers to return e-waste for recycling including the details of Deposit Refund Scheme, if applicable;

(g) the producer shall opt to implement Extended Producer Responsibility individually or collectively. In individual producer responsibility, producer may set up his own collection centre or implement take back system or both to meet Extended Producer Responsibility. In collective system, producers may tie-up as a member with a Producer Responsibility Organisation or with e-waste exchange or both. It shall be mandatory upon on the individual producer in every case to seek Extended Producer Responsibility - Authorisation from Central Pollution Control Board in accordance with the Form-1 and the procedure laid down in sub-rule (1) of rule 13;

(2) to provide information on the implementation of Deposit Refund Scheme to ensure collection of end-of-life products and their channelisation to authorised dismantlers or recyclers, if such scheme is included in the Extended Producer Responsibility Plan.

Provided that the producer shall refund the deposit amount that has been taken from the consumer or bulk consumer at the time of sale, along with interest at the prevalent rate for the period of the deposit at the time of take back of the end-oflife product;

(3) the import of electrical and electronic equipment shall be allowed only to producers having Extended Producer Responsibility authorisation;

(4) maintaining records in Form-2 of the e-waste handled and make such records available for scrutiny by the Central Pollution Control Board or the concerned State Pollution Control Board;

(5) filing annual returns in Form-3, to the Central Pollution Control Board on or before the 30th day of June following the financial year to which that return relates. In case of the Producer with multiple offices in a State, one annual return combining information from all the offices shall be filed;

(6) the Producer shall apply to the Central Pollution Control Board for authorisation in Form 1, which shall thereafter grant the Extended Producer Responsibility - Authorisation in Form 1(aa).

(7) Operation without Extended Producer Responsibility-Authorisation by any producer, as defined in this rule, shall be considered as causing damage to the environment.

6. Responsibilities of collection centres. - (1) collect e-waste on behalf of producer or dismantler or recycler or refurbisher including those arising from orphaned products;

Provided the collection centres established by producer can also collect e-waste on behalf of dismantler, refurbisher and recycler including those arising from orphaned products

(2) ensure that the facilities are in accordance with the standards or guidelines issued by Central Pollution Control Board from time to time;
(3) ensure that the e-waste collected by them is stored in a secured manner till it is sent to authorised dismantler or recycler as the case may be;
(4) ensure that no damage is caused to the environment during storage and transportation of e-waste;
(5) maintain records in Form-2 of the e-waste handled as per the guidelines of Central Pollution Control Board and make such records available for scrutiny by the Central Pollution Control Board or the concerned State Pollution Control Board as and when asked for.

7. Responsibilities of dealers. – (1) in the case the dealer has been given the responsibility of collection on behalf of the producer, the dealer shall collect the ewaste by providing the consumer a box, bin or a demarcated area to deposit ewaste, or through take back system and send the e-waste so collected to collection centre or dismantler or recycler as designated by producer;

(2) the dealer or retailer or e-retailer shall refund the amount as per take back system or Deposit Refund Scheme of the producer to the depositor of e-waste;
(3) every dealer shall ensure that the e-waste thus generated is safely transported to authorised dismantlers or recyclers;
(4) ensure that no damage is caused to the environment during storage and transportation of e-waste.

8. Responsibilities of the refurbisher. – (1) collect e-waste generated during the process of refurbishing and channelise the waste to authorised dismantler or recycler through its collection centre;

(2) make an application in Form 1(a) in accordance with the procedure laid down in sub-rule (4) of rule 13 to the concerned State Pollution Control Board for grant of one time authorisation;
   (a) the concerned State Pollution Control Board shall authorise the Refurbisher on one time basis as per Form 1 (bb) and authorisation would be deemed as considered if not objected to within a period of thirty days;
   (b) the authorised Refurbisher shall be required to submit details of e-waste generated to the concerned State Pollution Control Board on yearly basis;
(3) ensure that no damage is caused to the environment during storage and transportation of e-waste;
(4) ensure that the refurbishing process do not have any adverse effect on the health and the environment;

(5) ensure that the e-waste thus generated is safely transported to authorised collection centres or dismantlers or recyclers;

(6) file annual returns in Form-3 to the concerned State Pollution Control Board, on or before the 30th day of June following the financial year to which that return relates;

(7) maintain records of the e-waste handled in Form-2 and such records should be available for scrutiny by the appropriate authority.

9. Responsibilities of consumer or bulk consumer. – (1) consumers or bulk consumers of electrical and electronic equipment listed in Schedule I shall ensure that e-waste generated by them is channelised through collection centre or dealer of authorised producer or dismantler or recycler or through the designated take back service provider of the producer to authorised dismantler or recycler;

(2) bulk consumers of electrical and electronic equipment listed in Schedule I shall maintain records of e-waste generated by them in Form-2 and make such records available for scrutiny by the concerned State Pollution Control Board;

(3) consumers or bulk consumers of electrical and electronic equipment listed in Schedule I shall ensure that such end-of-life electrical and electronic equipment are not admixed with e-waste containing radioactive material as covered under the provisions of the Atomic Energy Act, 1962 (33 of 1962) and rules made there under;

(4) bulk consumers of electrical and electronic equipment listed in Schedule I shall file annual returns in Form-3, to the concerned State Pollution Control Board on or before the 30th day of June following the financial year to which that return relates. In case of the bulk consumer with multiple offices in a State, one annual return combining information from all the offices shall be filed to the concerned State Pollution Control Board on or before the 30th day of June following the financial year to which that return relates

10. Responsibilities of the dismantler. - (1)ensure that the facility and dismantling processes are in accordance with the standards or guidelines prescribed by Central

Pollution Control Board from time to time;

(2) obtain authorisation from the concerned State Pollution Control Board in accordance with the procedure under sub-rule (3) of rule 13;

(3) ensure that no damage is caused to the environment during storage and transportation of e-waste;

(4) ensure that the dismantling processes do not have any adverse effect on the health and the environment;

(5) ensure that dismantled e-waste are segregated and sent to the authorised recycling facilities for recovery of materials;

(6) ensure that non-recyclable or non-recoverable components are sent to authorised treatment storage and disposal facilities;

(7) maintain record of e-waste collected, dismantled and sent to authorised recycler in Form-2 and make such record available for scrutiny by the Central Pollution Control Board or the concerned State Pollution Control Board;

(8) file a return in Form-3, to the concerned State Pollution Control Board as the case may be, on or before 30th day of June following the financial year to which that return relates;

(9) not process any e-waste for recovery or refining of materials, unless he is authorised with concerned State Pollution Control Board as a recycler for refining and recovery of materials;

(10) operation without Authorisation by any dismantler, as defined in this rule, shall be considered as causing damage to the environment.

11. Responsibilities of the recycler. – (1) shall ensure that the facility and recycling processes are in accordance with the standards or guidelines prescribed by the

Central Pollution Control Board from time to time;

(2) obtain authorisation from concerned State Pollution Control Board in accordance with the procedure under the sub-rule (3) of rule 13;

(3) ensure that no damage is caused to the environment during storage and transportation of e-waste;

(4) ensure that the recycling processes do not have any adverse effect on the health and the environment;

(5) make available all records to the Central Pollution Control Board or the concerned State Pollution Control Board for inspection;

(6) ensure that the fractions or material not recycled in its facility is sent to the respective authorised recyclers;

(7) ensure that residue generated during recycling process is disposed of in an authorised treatment storage disposal facility;

(8) maintain record of e-waste collected, dismantled, recycled and sent to authorised recycler in Form-2 and make such record available for scrutiny by the Central Pollution Control Board or the concerned State Pollution Control Board;

(9) file annual returns in Form-3, to the concerned State Pollution Control Board as the case may be, on or before 30th day of June following the financial year to which that return relates;

(10) may accept waste electrical and electronic equipment or components not listed in Schedule I for recycling provided that they do not contain any radioactive material and same shall be indicated while taking the authorisation from concerned State Pollution Control Board;

(11) operation without Authorisation by any recycler, as defined in this rule, shall be considered as causing damage to the environment.

12. Responsibilities of State Government for environmentally sound management of E-waste. – (1) Department of Industry in State or any other government agency authorised in this regard by the State Government, to ensure earmarking or allocation of industrial space or shed for e-waste dismantling and recycling in the existing and upcoming industrial park, estate and industrial clusters;

(2) Department of Labour in the State or any other government agency authorised in this regard by the State Government shall:

a. ensure recognition and registration of workers involved in dismantling and recycling;
b. assist formation of groups of such workers to facilitate setting up dismantling facilities;
c. undertake industrial skill development activities for the workers involved in dismantling and recycling;
d. undertake annual monitoring and to ensure safety & health of workers involved in dismantling and recycling;

(3) State Government to prepare integrated plan for effective implementation of these provisions, and to submit annual report to Ministry of Environment, Forest and Climate Change.

CHAPTER III

PROCEDURE FOR SEEKING AND GRANT OF AUTHORISATION FOR MANAGEMENT OF E-WASTE

13. Procedure for Seeking and Grant of Authorisation. -

(1) **Extended Producer Responsibility - Authorisation of Producers.** – (i) every producer of electrical and electronic equipment listed in Schedule I, shall make an application for Extended Producer Responsibility - Authorisation within a period of ninety days starting from the date of these rules coming into force in Form-1 to Central Pollution Control Board;

(ii) on receipt of the application complete in all respects, the Central Pollution Control Board will carry out evaluation of the Extended Producer Responsibility Plan and on being satisfied that the producer has detailed out an effective system to manage Extended Producer Responsibility in the country, shall grant Extended Producer Responsibility - Authorisation, in Form 1(aa) within a period of one hundred and twenty days. The Extended Producer Responsibility - Authorisation shall be valid for a period of five years;

This authorisation shall include among others the targeted quantity of e-waste, product code wise, to be collected during the year. The actual target for collection of e-waste for dismantling or recycling will be fixed on the basis of quantity of electrical and electronic equipment, product code wise, placed in the market in the previous years and taking into consideration the average life of the equipment. The estimated quantity of e-waste generated during the current year will be indicated by the producer and the quantity expected to be collected with the collection scheme proposed to be implemented by the producer will be indicated in the Extended Producer Responsibility plan. The Central Pollution Control Board shall fix the targets in accordance with Schedule III.

(iii) the Central Pollution Control Board, after giving reasonable opportunity of being heard to the applicant shall refuse to grant Extended Producer Responsibility – Authorisation;

(iv) in the event of refusal of Extended Producer Responsibility - Authorisation by the Central Pollution Control Board, the producer will forfeit his right to put any Electrical and Electronic Equipment in the market till such time the Extended Producer Responsibility - Authorisation is granted;

(v) the Central Pollution Control Board after grant of Extended Producer Responsibility - Authorisation shall forward the Extended Producer Responsibility Plan to respective State Pollution Control Board for monitoring;

(vi) an application for the renewal of Extended Producer Responsibility-Authorisation shall be made in Form-1 before one hundred and twenty days of its expiry to Central Pollution Control Board. The Central Pollution Control Board may renew the authorisation for a period of five years after receipt of compliance report from the concerned State Pollution Control Board which shall submit the compliance report to Central Pollution Control Board within sixty days from the date of the receipt of the application. In case of non receipt of the compliance report from the State Pollution Control Board within stipulated time period of sixty days, Central Pollution Control Board may renew the Extended Producer ResponsibilityAuthorisation after examining such case on merit basis, subject to no report of violation of the provisions of the Act or the rules made there under or the conditions specified in the Extended Producer Responsibility - Authorisation;

(vii) every producer of Electrical and Electronic Equipment listed in Schedule I, shall take all steps, wherever required, to comply with the conditions specified in the Extended Producer Responsibility – Authorisation;

(viii) the concerned State Pollution Control Board shall monitor the compliance of Extended Producer Responsibility - Authorisation, take cognizance of any noncompliance and inform Central Pollution Control Board for taking action, as necessary;

(ix) Central Pollution Control Board shall conduct random check and if in its opinion, the holders of the Extended Producer Responsibility - Authorisation has failed to comply with any of the conditions of the authorisation or with any provisions of the Act or these rules and after giving a reasonable opportunity of being heard and after recording reasons thereof in writing cancel or suspend the Extended Producer Responsibility - Authorisation issued under these rules for such period as it considers necessary in the public interest and inform the concerned State Pollution Control Board within ten days of cancellation.

(x) the Central Pollution Control Board shall maintain an online register of Extended Producer Responsibility - Authorisation granted with conditions imposed under these rules for environmentally sound management of e-waste, and which shall be accessible to any citizen of the country.

(xi) The producer authorised under the provision of this rule shall maintain records in Form-2 and shall file annual returns of its activities of previous year in Form-3 to the Central Pollution Control Board on or before 30th day of June of every year;

(2) **Authorisation of Manufacturer. –** (i) the manufacturer generating e-waste shall obtain an authorisation from the concerned State Pollution Control Board;

(ii) the manufacturer shall make an application for authorisation, within a period of ninety days from the date of these rules coming into force in Form 1(a) to the concerned State Pollution Control Board for grant of authorisation;

(iii) on receipt of the application complete in all respects for the authorisation, the concerned State Pollution Control Board may, after such enquiry as it considers necessary and on being satisfied that the applicant possesses appropriate facilities, technical capabilities and equipment to handle e-waste safely, grant within a period of one hundred and twenty days an authorisation in Form 1(bb) to the applicant to carry out safe operations in the authorised place only, which shall be valid for a period of five years;

(iv) the concerned State Pollution Control Board after giving reasonable opportunity of being heard to the applicant may refuse to grant any authorisation;

(v) every person authorised under these rules shall maintain the record of e-waste handled by them in Form-2 and prepare and submit to the concerned State Pollution Control Board, an annual return containing the details specified in Form3 on or before the 30th day of June following the financial year to which that return relates;

(vi) an application for the renewal of an authorisation shall be made in Form-1(a) before one hundred and twenty days of its expiry and the concerned State Pollution Control Board may renew the authorisation for a period of five years after examining each case on merit and subject to the condition that there is no report of violation of the provisions of the Act or the rules made thereunder or the conditions specified in the authorisation;

(vii) manufacturer shall take all steps to comply with the conditions specified in the authorisation;

(viii) the concerned State Pollution Control Board shall maintain an online register of authorisations granted with conditions imposed under these rules for environmentally sound management of e-waste, and which shall be accessible to any citizen of the country.

(3) **Procedure for grant of authorisation to dismantler or recycler.** - (i) every Dismantler or Recycler of e-waste shall make an application, within a period of one hundred and twenty days starting from the date of coming into force of these rules, in Form-4 in triplicate to the concerned State Pollution Control Board accompanied with a copy of the following documents for the grant or renewal of authorisation, namely:-

(a) consent to establish granted by the concerned State Pollution Control Board under the Water (Prevention and Control of Pollution) Act, 1974, (25 of 1974) and the Air (Prevention and Control of Pollution) Act, 1981(21 of 1981);

(b) certificate of registration issued by the District Industries Centre or any other government agency authorised in this regard;

(c) proof of installed capacity of plant and machinery issued by the District Industries Centre or any other government agency authorised in this behalf;

(d) in case of renewal, a certificate of compliance of effluent and emission standards, treatment and disposal of hazardous wastes as applicable from the concerned State Pollution Control Board or any other agency designated for this purpose:

Provided that any person authorised or registered under the provisions of the Hazardous Wastes (Management, Handling and Transboundary Movements) Rules, 2008, and the E-waste (Management & Handling) Rules, 2011 prior to the date of coming into force of these rules shall not be required to make an application for authorisation till the period of expiry of such authorisation or registration:

(ii) the concerned State Pollution Control Board, on being satisfied that the application is complete in all respects and that the applicant is utilising environmentally sound technologies and possess adequate technical capabilities, requisite facilities and equipment to dismantle or recycle and process e-waste in compliance to the guidelines specified by Central Pollution Control Board from time to time and through site inspection, may grant authorisation to such applicants stipulating therein necessary conditions as deemed necessary for carrying out safe operations in the authorised place only;

(iii) the concerned State Pollution Control Board shall dispose of the application for authorisation within a period of one hundred and twenty days from the date of the receipt of such application complete in all respects;

(iv) the authorisation granted under these rules shall be valid for a period of five years from the date of its issue and shall be accompanied with a copy of the field inspection report signed by that Board indicating the adequacy of facilities for dismantling or recycling of e-waste and compliance to the guidelines specified by Central Pollution Control Board from time to time;

(v) the concerned State Pollution Control Board may refuse, cancel or suspend an authorisation granted under these rules, if it has reasons to believe that the authorised dismantler or recycler has failed to comply with any of the conditions of authorisation, or with any provisions of the Act or rules made thereunder, after giving an opportunity to the dismantler or recycler to be heard and after recording the reasons thereof;

(vi) an application for the renewal of authorisation shall be made in Form - 4 before one hundred and twenty days of its expiry and the concerned State Pollution Control Board may renew the authorisation for a period of five years after examining each case on merit and subject to the condition that there is no report of violation of the provisions of the Act or the rules made there under or the conditions specified in the authorisation;

(vii) the Dismantler and Recycler shall maintain records of the e-waste purchased, processed in Form-2 and shall file annual returns of its activities of previous year in Form-3 to the concerned State Pollution Control Board on or before 30th day of June of every year;

(viii) the Central Government and the Central Pollution Control Board may issue guidelines for standards of performance for dismantling and recycling processes from time to time.

(4) **Procedure for grant of authorisation to refurbisher.** – (i) every refurbisher of e-waste shall make an application, with in a period of one hundred and twenty days starting from the date of coming into force of these rules, in Form 1 (a) in triplicate to the concerned State Pollution Control Board accompanied with a copy of the following documents for the grant or renewal of authorisation, namely:-

(a) consent to establish granted by the concerned State Pollution Control Board under the Water (Prevention and Control of Pollution) Act, 1974, (25 of 1974) and the Air (Prevention and Control of Pollution) Act, 1981 (21 of 1981);

(b) certificate of registration issued by the District Industries Centre or any other government agency authorised in this regard;

(c) proof of installed capacity of plant and machinery issued by the District Industries Centre or any other government agency authorised in this behalf.

(ii) the concerned State Pollution Control Board, on being satisfied that the application is complete in all respects and complies with the guidelines prescribed by Central Pollution Control Board from time to time, may grant one time authorisation in Form 1 (bb) to such applicants stipulating therein necessary conditions as deemed necessary for carrying out refurbishing activities in the authorised place only;

(iii) the concerned State Pollution Control Board shall dispose of the application for authorisation within a period of one hundred and twenty days from the date of the receipt of such application complete in all respects;

(iv) the concerned State Pollution Control Board may refuse, cancel or suspend a authorisation granted under these rules, if it has reasons to believe that the authorised refurbisher has failed to comply with any of the conditions of authorisation, or with any provisions of the Act or rules made thereunder, after giving an opportunity to the refurbisher to be heard and after recording the reasons thereof;

(v) the Refurbisher shall maintain records of the e-waste purchased and refurbished in Form-2 and shall file annual returns of its activities of previous year in Form-3 to the concerned State Pollution Control Board on or before 30th day of June of every year.

14. Power to suspend or cancel an authorisation.- (1) The State Pollution Control Board may, if in its opinion, the holder of Manufacturer or Dismantler or Recycler or Refurbisher Authorisation has failed to comply with any of the conditions of the authorisation or with any provisions of the Act or these rules and after giving a reasonable opportunity of being heard and after recording reasons thereof in writing cancel or suspend the authorisation issued under these rules for such period as it considers necessary in the public interest and inform Central Pollution Control Board within ten days of cancellation;

(2) The Central Pollution Control Board, if in its opinion, the holders of the Extended Producer Responsibility- Authorisation has failed to comply with any of the conditions of the authorisation or with any provisions of the Act or these rules and after giving a reasonable opportunity of being heard and after recording reasons thereof in writing cancel or suspend the Extended Producer Responsibility- Authorisation issued under these rules for such period as it considers necessary in the public interest and inform State Pollution Control Boards or Pollution Control Committees within ten days of cancellation;

(3) Upon suspension or cancellation of the authorisation, the Central Pollution Control Board or State Pollution Control Board may give directions to the persons whose authorisation has been suspended or cancelled for the safe storage and management of the e-waste and such persons shall comply with such directions.

CHAPTER IV

15. Procedure for storage of e-waste. - Every manufacturer, producer, bulk consumer, collection centre, dealer, refurbisher, dismantler and recycler may store the e-waste for a period not exceeding one hundred and eighty days and shall maintain a record of collection, sale, transfer and storage of wastes and make these records available for inspection:

Provided that the concerned State Pollution Control Board may extend the said period up to three hundred and sixty five days in case the waste needs to be specifically stored for development of a process for its recycling or reuse.

CHAPTER V

REDUCTION IN THE USE OF HAZARDOUS SUBSTANCES IN THE MANUFACTURE OF ELECTRICAL AND ELECTRONIC EQUIPMENT AND THEIR COMPONENTS OR CONSUMABLES OR PARTS OR SPARES

16. Reduction in the use of hazardous substances in the manufacture of electrical and electronic equipment and their components or consumables or parts or spares. – (1) Every producer of electrical and electronic equipment and their components or consumables or parts or spares listed in Schedule I shall ensure that, new Electrical and Electronic Equipment and their components or consumables or parts or spares do not contain Lead, Mercury, Cadmium, Hexavalent Chromium, polybrominated biphenyls and polybrominated diphenyl ethers beyond a maximum concentration value of 0.1% by weight in homogenous materials for lead, mercury, hexavalent chromium, polybrominated biphenyls and polybrominated diphenyl ethers and of 0.01% by weight in homogenous materials for cadmium.

(2) Components or consumables or parts or spares required for the electrical and electronic equipment placed in the market prior to 1st May, 2014 may be

exempted from the provisions of sub-rule (1) of rule 16 provided Reduction of Hazardous Substances compliant parts and spares are not available.

(3) The applications listed in Schedule II shall be exempted from provisions of subrule (1) of rule 16.

(4) Every producer of applications listed in Schedule II shall ensure that the limits of hazardous substances as given in Schedule II are to be complied.

(5) Every producer shall provide the detailed information on the constituents of the equipment and their components or consumables or parts or spares alongwith a declaration of conformance to the Reduction of Hazardous Substances provisions in the product user documentation.

(6) Imports or placement in the market for new electrical and electronic equipment shall be permitted only for those which are compliant to provisions of sub-rule (1) and sub rule (4) of rule 16.

(7) Manufacture and supply of electrical and electronic equipment used for defence and other similar strategic applications shall be excluded from provisions of subrule (1) of rule 16.

(8) Every producer while seeking Extended Producer Responsibility - Authorisation will provide information on the compliance of the provisions of sub-rule (1) of rule 16. This information shall be in terms of self-declaration.

(9) Central Pollution Control Board shall conduct random sampling of electrical and electronic equipment placed on the market to monitor and verify the compliance of Reduction of Hazardous Substances provisions and the cost for sample and testing shall be borne by the Producer. The random sampling shall be as per the guidelines of Central Pollution Control Board.

(10) If the product does not comply with Reduction of Hazardous Substances provisions, the Producers shall take corrective measures to bring the product into compliance and withdraw or recall the product from the market, within a reasonable period as per the guidelines of the Central Pollution Control Board.

(11) Central Pollution Control Board shall publish the methods for sampling and analysis of Hazardous Substances as listed in sub-rule(1) of rule 16 with respect to the items listed in Schedule I and II and also enlist the labs for this purpose.

CHAPTER VI

MISCELLANEOUS

17. Duties of authorities. - Subject to other provisions of these rules, the authorities shall perform duties as specified in Schedule IV.

18. Annual Report. – (1) The concerned State Pollution Control Board shall prepare and submit to the Central Pollution Control Board an annual report with regard to the implementation of these rules by the 30th day of September every year in Form-5.

(2) The Central Pollution Control Board shall prepare the consolidated annual review report on management of e-waste and forward it to the Central Government along with its recommendations before the 30th day of December every year.

19. Transportation of e-waste. –The transportation of e-waste shall be carried out as per the manifest system whereby the transporter shall be required to carry a document (three copies) prepared by the sender, giving the details as per Form-6:

Provided that the transportation of waste generated from manufacturing or recycling destined for final disposal to a treatment, storage and disposal facility shall follow the provisions under Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008.

20. Accident reporting.- Where an accident occurs at the facility processing e-waste or during transportation of e-waste, the producer, refurbisher, transporter, dismantler, or recycler, as the case may be, shall report immediately to the concerned State Pollution Control Board about the accident through telephone and e-mail.

21. Liability of manufacturer, producer, importer, transporter, refurbisher, dismantler and recycler.- (1) The manufacturer, producer, importer, transporter, refurbisher, dismantler and recycler shall be liable for all damages caused to the environment or third party due to improper handling and management of the e-waste;

(2) The manufacturer, producer, importer, transporter, refurbisher, dismantler and recycler shall be liable to pay financial penalties as levied for any violation of the provisions under these rules by the State Pollution Control Board with the prior approval of the Central Pollution Control Board.

22. Appeal.- (1) Any person aggrieved by an order of suspension or cancellation or refusal of authorisation or its renewal passed by the Central Pollution Control Board or State Pollution Control Board may, within a period of thirty days from the date on which the order is communicated to him, prefer a appeal in Form 7 to the Appellate Authority comprising of the Environment Secretary of the State.

(2) The Appellate Authority may entertain the appeal after expiry of the said period of thirty days if it is satisfied that the appellant was prevented by sufficient cause from filing the appeal in time.

(3) Every appeal filed under this rule shall be disposed of within a period of sixty days from the date of its filing.

23. The collection, storage, transportation, segregation, refurbishment, dismantling, recycling and disposal of e-waste shall be in accordance with the procedures prescribed in the guidelines published by the Central Pollution Control Board from time to time. Implementation of e-waste (Management and Handling) Amendment Rules, 2011 shall be in accordance with the guidelines prescribed by the Central Pollution Control Board from time to time.

24. Urban Local Bodies (Municipal Committee or Council or Corporation) shall ensure that e-waste pertaining to orphan products is collected and channelised to authorised dismantler or recycler.

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SCHEDULE I

[See rules 2, 3(j), 3(y), 3(aa) and 3(ff); 5; 9; 11(10); 13 (1) (i), 13 (1) (vii) and 16(1), 16(11)]

Categories of electrical and electronic equipment including their components, consumables, parts and spares covered under the rules

Sr. No.	Categories of electrical and electronic equipment	Electrical and electronic equipment code
i.	**Information technology and telecommunication equipment :**	
	Centralised data processing: Mainframes, Minicomputers	ITEW1
	Personal Computing: Personal Computers (Central Processing Unit with input and output devices)	ITEW2
	Personal Computing: Laptop Computers(Central Processing Unit with input and output devices)	ITEW3
	Personal Computing: Notebook Computers	ITEW4
	Personal Computing: Notepad Computers	ITEW5
	Printers including cartridges	ITEW6
	Copying equipment	ITEW7
	Electrical and electronic typewriters	ITEW8
	User terminals and systems	ITEW9
	Facsimile	ITEW10
	Telex	ITEW11
	Telephones	ITEW12
	Pay telephones	ITEW13
	Cordless telephones	ITEW14
	Cellular telephones	ITEW15
	Answering systems	ITEW16
ii.	**Consumer electrical and electronics:**	
	Television sets (including sets based on (Liquid Crystal Display and Light Emitting Diode technology)	CEEW1
	Refrigerator	CEEW2

	Washing Machine	CEEW3
	Air-conditioners excluding centralised air conditioning plants	CEEW4
	Fluorescent and other Mercury containing lamps	CEEW5

SCHEDULE II

[See rules 16 (3), 16 (4) and 16 (11)]

Applications, which are exempted from the requirements of sub-rule (1) of rule 16	
	Substance
1	Mercury in single capped (compact) fluorescent lamps not exceeding (per burner):
1(a)	For general lighting purposes <30 W : 2.5 mg
1(b)	For general lighting purposes ≥ 30 W and <50 W : 3.5mg
1(c)	For general lighting purposes ≥ 50 W and <150 W : 5mg
1(d)	For general lighting purposes ≥150 W : 15 mg
1(e)	For general lighting purposes with circular or square structural shape and tube diameter ≤17 mm : 7mg
1(f)	For special purposes:5 mg
2(a)	Mercury in double-capped linear fluorescent lamps for general lighting purposes not exceeding (per lamp):
2(a)(1)	Tri-band phosphor with normal life time and a tube diameter < 9mm (e.g. T2): 4mg
2(a)(2)	Tri-band phosphor with normal life time and a tube diameter ≥ 9 mm and ≤ 17 mm (e.g. T5): 3 mg
2(a)(3)	Tri- band phosphor with normal life time and a tube diameter >17 mm and ≤ 28 mm(e.g. T8): 3.5 mg
2(a)(4)	Tri-band phosphor with normal life time and a tube diameter >28 mm (e.g. T 12):3.5 mg
2(a)(5)	Tri-band phosphor with long life time (≥25000 h):5mg
2(b)	Mercury in other fluorescent lamps not exceeding(per lamp):
2(b)(1)	Linear halophosphate lamps with tube >28 mm (e.g. T 10 and T12):10 mg
2(b)(2)	Non-linear halophosphate lamps(all diameters):15mg
2(b)(3)	Non-linear tri-band phosphor lamps with tube diameter >17 mm(e.g.T9): 15 mg
2(b)(4)	Lamps for other general lighting and special purposes (e.g. induction lamps):15mg
3	Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL)for special purposes not exceeding (per lamp):

3(a)	Short length(≤ 500 mm):3.5mg
3(b)	Medium length(>500 mm and≤1500 mm): 5mg
3(c)	Long length(>1500 mm): 13mg
4(a)	Mercury in other low pressure discharge lamps (per lamp): 15mg
4(b)	Mercury in High Pressure Sodium(vapour) lamps for general lighting purposes not exceeding (per burner)in lamps with improved colour rendering index Ra>60:

4(b)-I	P ≤155 W : 30 mg
4(b)-II	155 W < P ≤405 W : 40 mg
4(b)-III	P >405 W: 40 mg
4(c)	Mercury in other High Pressure Sodium(vapour)lamps for general lighting purposes not exceeding (per burner):
4(c)-I	P≤155 W:25mg
4(c)-II	155 W < P ≤ 405 W:30 mg
4(c)-III	P >405 W:40 mg
4(d)	Mercury in High Pressure Mercury (vapour) lamps (HPMV)
4(e)	Mercury in metal halide lamps (MH)
4(f)	Mercury in other discharge lamps for special purposes not specifically mentioned in this Schedule
5(a)	Lead in glass of cathode ray tubes
5(b)	Lead in glass of fluorescent tubes not exceeding 0.2% by weight
6(a)	Lead as an alloying element in steel for machining purposes and in galvanized steel containing up to 0.35% lead by weight
6(b)	Lead as an alloying element in aluminium containing up to 0.4% lead by weight
6(c)	Copper alloy containing up to 4% lead by weight
7(a)	Lead in high melting temperature type solders (i.e. lead-based alloys containing 85% by weight or more lead)
7(b)	Lead in solders for servers, storage and storage array systems, network infrastructure equipment for switching, signalling, transmission, and network management for telecommunications
7(c)-I	Electrical and electronic components containing lead in a glass or ceramic other than dielectric ceramic in capacitors, e.g. piezoelectronic devices, or in a glass or ceramic matrix compound.

7(c)-II	Lead in dielectric ceramic in capacitors for a rated voltage of 125 V AC or 250 V DC or higher
7(c)-III	Lead in dielectric ceramic in capacitors for a rated voltage of less than 125 V AC or 250 V DC
8(a)	Cadmium and its compounds in one shot pellet type thermal cut-offs
8(b)	Cadmium and its compounds in electrical contracts
9	Hexavalent chromium as an anticorrosion agent of the carbon steel cooling system in absorption refrigerators up to 0.75% by weight in the cooling solution
9(b)	Lead in bearing shells and bushes for refrigerant-containing compressors for heating, ventilation, air conditioning and refrigeration (HVACR) application.

11(a)	Lead used in C-press compliant pin connector systems
11(b)	Lead used in other than C-press compliant pin connector systems
12	Lead as a coating material for the thermal conduction module C- ring
13(a)	Lead in white glasses used for optical applications
13(b)	Cadmium and lead in filter glasses and glasses used for reflectance standards.
14	Lead in solders consisting of more than two elements for the connection between the pins and the package of microprocessors with a lead content of more than 80% and less than 85% by weight
15	Lead in solders to complete a viable electrical connection between semiconductor die and carrier within integrated circuit flip chip packages.
16	Lead in linear incandescent lamps with silicate coated tubes
17	Lead halide as radiant agent in high intensity discharge (HID) lamps used for professional reprography applications.
18(a)	Lead as activator in the fluorescent powder (1% lead by weight or less) of discharge lamps when used as specialty lamps for diazoprinting reprography, lithography, insect traps, photochemical and curing processes containing phosphors such as SMS ($(Sr, Ba)_2Mg$ $Si_2O_7:Pb$)
18(b)	Lead as activator in the fluorescent powder (1% lead by weight or less) of discharge lamps when used as sun tanning lamps containing phosphors such as BSP ($Ba\ Si_2O_5:Pb$)
19	Lead with PbBiSn-Hg and PblnSn-Hg in specific compositions as main amalgam and with PbSn-Hg as auxiliary amalgam in very compact energy saving lamps (ESL)
20	Lead oxide in glass used for bonding front and rear substrates of flat fluorescent lamps used for Liquid Crystal Displays (LCDs)

21	Lead and cadmium in printing inks for the application of enamels on glasses, such as borosilicate and soda lime glasses
23	Lead in finishes of fine pitch components other than connectors with a pitch of 0.65 mm and less
24	Lead in solders for the soldering to machined through hole discoidal and planar array ceramic multilayer capacitors
25	Lead oxide in surface conduction electron emitter displays (SED) used in structural elements, notably in the seal frit and frit ring.
26	Lead oxide in the glass envelope of black light blue lamps
27	Lead alloys as solder for transducers used in high-powered (designated to operate for several hours at acoustic power levels of 125 dB SPL and above) loudspeakers
29	Lead bound in crystal glass
30	Cadmium alloys as electrical/mechanical solder joints to electrical conductors located directly on the voice coil in transducers used in high-powered loudspeakers with sound pressure levels of 100 dB(A) and more
31	Lead in soldering materials in mercury free flat fluorescent lamps (which e.g. are used for liquid crystal displays, design or industrial lighting)
32	Lead oxide in seal frit used for making window assemblies for Argon and Krypton laser tubes
33	Lead in solders for the soldering of thin copper wires of 100 µm diameter and less in power transformers
34	Lead in cermet-based trimmer potentiometer elements
36	Mercury used as a cathode sputtering inhibitor in DC plasma displays with a content up to 30 mg per display
37	Lead in the plating layer of high voltage diodes on the basis of a zinc borate glass body
38	Cadmium and cadmium oxide in thick film pastes used on aluminium bonded beryllium oxide
39	Cadmium in colour converting II-VI LEDs (<10 µg Cd per mm^2 of lightemitting area) for use in solid state illumination or display systems.

SCHEDULE III

[See rules 5 (1) (a) and 13 (1) (ii)]

Targets for Extended Producer Responsibility - Authorisation

No.	Year	E-Waste Collection Target (Number/Weight)
(i)	During first two year of implementation of rules	30% of the quantity of waste generation as indicated in Extended Producer Responsibility Plan.
(ii)	During third and fourth years of implementation of rules	40% of the quantity of waste generation as indicated in Extended Producer Responsibility Plan.
(iii)	During Fifth and Sixth years of implementation of rules	50% of the quantity of waste generation as indicated in Extended Producer Responsibility Plan.
(iv)	Seventh year onward of implementation of rules	70% of the quantity of waste generation as indicated in Extended Producer Responsibility Plan.

SCHEDULE IV

[See rule (17)]

LIST OF AUTHORITIES AND CORREPONDING DUTIES

Sr. No	AUTHORITY	CORRESPONDING DUTIES
1.	Central Pollution Control Board, Delhi	(i) Grant and Renewal of Extended Producer Responsibility - Authorisation and monitoring of its compliance. (ii) Maintain information on Extended Producer Responsibility - Authorisation on its web site. (iii) Set and revise targets for collection of e-waste from time to time. (iv) Coordination with State Pollution Control Boards (v) Preparation of Guidelines for Environmentally Sound Management of e-waste. (vi) Conduct random check for ascertaining compliance of the e-waste rules and identification of such importers or producers who have not applied for Extended Producer Responsibility authorisation or are not complying with RoHS provision. Wherever necessary, Central Pollution Control Board will seek the help of customs department or any other agency of the Government of India. (vii) Conduct random inspection of dismantler or recycler or refurbisher. (viii) Documentation, compilation of data on e-waste and uploading on websites of Central Pollution Control Board (ix) Actions against violation of these rules. (x) Conducting training programmes. (xi) Submit Annual Report to the Ministry. (xii) Enforcement of provisions regarding reduction in use of hazardous substances in manufacture of electrical and electronic equipment. (xiii) Interaction with IT industry for reducing hazardous substances. (xiv) Set and revise targets for compliance to the reduction in use of hazardous substance in manufacture of electrical and electronic equipment from time to time. (xv) Any other function delegated by the Ministry under these rules from time to time.

2.	State Pollution Control Boards or Committees of Union territories	(i) Inventorisation of e-waste. (ii) Grant and renewal of authorisation to manufacturers, dismantlers, recyclers and refurbishers. (iii) Monitoring and compliance of Extended Producer Responsibility - Authorisation as directed by Central Pollution Control Board and that of dismantlers, recyclers and refurbishers authorisation. (iv) Conduct random inspection of dismantler or recycler or refurbisher. (v) Maintain online information regarding authorisation granted to manufacturers, dismantlers, recyclers and refurbishers.
Sr. No	**AUTHORITY**	**CORRESPONDING DUTIES**
		(vi) Implementation of programmes to encourage environmentally sound recycling. (vii) Action against violations of these rules. (viii) Any other function delegated by the Ministry under these rules.
3.	Urban Local Bodies (Municipal Committee or Council or Corporation)	(i) To ensure that e-waste if found to be mixed with Municipal Solid Waste is properly segregated, collected and is channelised to authorised dismantler or recycler. (ii) To ensure that e-waste pertaining to orphan products is collected and channelised to authorised dismantler or recycler.
4.	Port authority under Indian Ports Act, 1908 (15 of 1908) and Customs Authority under the Customs Act, 1962 (52 of 1962)	(i) Verify the Extended Producer Responsibility - Authorisation. (ii) Inform Central Pollution Control Board of any illegal traffic for necessary action. (iii) Take action against importer for violations under the Indian Ports Act, 1908/Customs Act, 1962.

****** FORM-1**

[See Rules 5(1) (g), 13(1) (i), 13(1) (vi)]

Applicable to producers seeking Extended Producer Responsibility - Authorisation

The application form should contain the following information:

1.	Name and full address along with telephone numbers, e-mail and other contact details of Producer (It should be the place from where sale in entire country is being managed)	:	

2.	Name of the Authorised Person and full address with e-mail, telephone and fax number	:	
3.	Name, address and contact details of Producer Responsibility Organisation, if any with full address, e-mail, telephone and fax number, if engaged for implementing the Extended Producer Responsibility	:	
4.	Details of electrical and electronic equipment placed on market year-wise during previous 10 years in the form of Table 1 as given below:	:	

Table 1: Details of Electrical and Electronic Equipment placed on the market in previous years - Code wise

Sr. No.	**Electrical and Electronic Equipment Item**	**Electrical and Electronic Equipment Code**	**Quantity, number and weight placed on market (year-wise)**									
A	**Information technology and telecommunication equipment:**											
1	Centralised data processing: Mainframes, Minicomputers	ITEW1										
2	Personal Computing: Personal Computers (Central Processing Unit with input and output devices)	ITEW2										
3	Personal Computing: Laptop Computers(Central Processing Unit with input and	ITEW3										
	output devices)											
4	Personal Computing: Notebook Computers	ITEW4										
5	Personal Computing: Notepad Computers	ITEW5										

6	Printers including cartridges	ITEW6										
7	Copying equipment	ITEW7										
8	Electrical and electronic typewriters	ITEW8										
9	User terminals and systems	ITEW9										
10	Facsimile	ITEW10										
11	Telex	ITEW11										
12	Telephones	ITEW12										
13	Pay telephones	ITEW13										
14	Cordless telephones	ITEW14										
15	Cellular telephones	ITEW15										
16	Answering systems	ITEW16										
B	**Consumer electrical and electronics:**											
17	Television sets (including sets based on (Liquid Crystal Display and Light Emitting Diode technology)	CEEW1										
18	Refrigerator	CEEW2										
19	Washing Machine	CEEW3										
20	Air-conditioners excluding centralised air conditioning plants	CEEW4										
21	Fluorescent and other Mercury containing lamps	CEEW5										

5. Estimated generation of Electrical and Electronic Equipment waste item-wise and estimated collection target for the forthcoming year in the form of Table 2 including those being generated from their service centres, as given below:

Table 2: Estimated generation of Electrical and Electronic Equipment waste item-wise and estimated collection target for the forthcoming year

Sr. No.	Item	Estimated waste electrical and electronic equipment generation Number and weight	Targeted collection Number and weight

6. Extended Producer Responsibility Plans:

   (a) Please provide details of your overall scheme to fulfil Extended Producer Responsibility obligations including targets. This should comprise of general scheme of collection of used/waste Electrical and Electronic Equipment from the Electrical and Electronic Equipment placed on the market earlier such as through dealers and collection centres, Producer Responsibility Organisation, through buy-back arrangement, exchange scheme, Deposit Refund Scheme, etc. whether directly or through any authorised agency and channelising the items so collected to authorised recyclers.

   (b) Provide the list with addresses along with agreement copies with dealers, collection centres, recyclers, Treatment, Storage and Disposal Facility, etc.
   under your scheme.

7. Estimated budget for Extended Producer Responsibility and allied initiatives to create consumer awareness.

8. Details of proposed awareness programmes.

9. Details for Reduction of Hazardous Substances compliance (to be filled if applicable):

(a) Whether the Electrical and Electronic Equipment placed on market complies with the rule 16 (1) limits with respect to lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls and polybrominateddiphenyl ethers;

(b)Provide the technical documents (Supplier declarations, Materials declarations/Analytical reports) as evidence that the Reduction of Hazardous Substances (RoHS) provisions are complied by the product based on standard EN 50581 of EU;

(c) Documents required:

i. Extended Producer Responsibility plan;

ii. Copy of the permission from the relevant Ministry/Department for selling their product;

iii. Copies of agreement with dealers, collection centre, recyclers, Treatment, Storage and Disposal Facility, etc.; iv. Copy of Directorate General of Foreign Trade license/permission as applicable;

v. Self-declaration regarding Reduction of Hazardous Substances provision;

vi. Any other document as required.

(Authorised signature) Place: __________

Date: __________

FORM 1(a)

[See rules 4(2), 8 (2), 13(2) (ii), 13(2) (vi) and 13(4) (i)]

APPLICATION FOR OBTAINING AUTHORISATION FOR GENERATION OR STORAGE OR TREATMENT OR DISPOSAL OF E-WASTE BY MANUFACTURER OR REFURBISHER*

From: ....

....

To

The Member Secretary,

.... Pollution Control Board or……………… Pollution Control Committee

....

....

Sir,

I / We hereby apply for authorisation/renewal of authorisation under rule 13(2) (i) to 13(2) (viii) and/or 13 (4) (i) of the E-Waste (Management) Rules, 2016 for collection/storage/ transportation/ treatment/ refurbishing/disposal of e-wastes.

For Office Use Only

Code No. :

Whether the unit is situated in a critically polluted area as identified by Ministry of

Environment and Forests (yes/no);

To be filled in by Applicant

---

1. Name and full address:
2. Contact Person with designation and contact details such as telephone Nos, Fax. No. and E-mail:
3. Authorisation required for (Please tick mark appropriate activity/ies*)
   - (i) Generation during manufacturing or refurbishing* ☐
   - (ii) Treatment, if any ☐
   - (iii) Collection, Transportation, Storage ☐
   - (iv) Refurbishing ☐

4. E-waste details:
   - (a) Total quantity e-waste generated in MT/A
   - (b) Quantity refurbished (applicable to refurbisher)

(c) Quantity sent for recycling
(d) Quantity sent for disposal

5. Details of Facilities for storage/handling/treatment/refurbishing:

6. In case of renewal of authorisation previous authorisation no. and date and details of annual returns:

Place : ___________ Signature _______________

(Name_________________)

Date : ___________

Designation: ____________

Note:-

(1) * The authorisation for e-waste may be obtained along with authorisation for hazardous waste under the Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008, if applicable.

(2) Wherever necessary, use additional sheets to give requisite and necessary details.

FORM 1 (aa)

[See rules 5 (6) and 13(1)(ii)]

FORMAT OF EXTENDED PRODUCER RESPONSIBILITY - AUTHORISATION

[Extended Producer Responsibility Authorisation for Producer of the Electrical & Electronic Equipment]

Ref: Your application for Grant of Extended Producer Responsibility - Authorisation for following Electrical & Electronic Equipment under E-Waste (Management) Rules, 2016

1. Number of Authorisation:

   Date:

2. **M/s. -------------------** is hereby granted Extended Producer Responsibility - Authorisation based on:
   (a) overall Extended Producer Responsibility plan
   (b) proposed target for collection of e-waste

3. The Authorisation shall be valid for a period of ___ years from date of issue with following conditions:

   (i) you shall strictly follow the approved Extended Producer Responsibility plan, a copy of which is enclosed herewith;

   (ii) you shall ensure that collection mechanism or centre are set up or designated as per the details given in the Extended Producer Responsibility plan. Information on collection mechanism/centre including the state-wise setup should be provided;

   (iii) you shall ensure that all the collected e-waste is channelised to authorised dismantler or recycler designated as per the details. Information on authorised dismantler or recycler designated state-wise should be provided;

   (iv) you shall maintain records, in Form-2 of these Rules, of e-waste and make such records available for scrutiny by Central Pollution Control Board;

   (v) you shall file annual returns in Form-3 to the Central Pollution Control Board on or before 30th day of June following the financial year to which that returns relates;

   (vi) General Terms & Conditions of the Authorisation:

a. The authorisation shall comply with provisions of the Environment (Protection) Act, 1986 and the Rules made there under;

b. The authorisation or its renewal shall be produced for inspection at the request of an officer authorised by the Central Pollution Control Board;

c. Any change in the approved Extended Producer Responsibility plan should be informed to Central Pollution Control Board on which decision shall be communicated by Central Pollution Control Board within sixty days;

d. It is the duty of the authorised person to take prior permission of the concerned State Pollution Control Boards and Central Pollution Control Board to close down the facility;

e. An application for the renewal of authorisation shall be made as laid down in sub-rule (vi) of rule of 13(1) the E-Waste (Management) Rules, 2016;

f. The Board reserves right to cancel/amend/revoke the authorisation at any time as per the Policy of the Board or Government.

Authorized signatory
(with designation)

To, Concerned Producer

Copy to:

1. Member Secretary, Concerned State.
2. In-charge, concerned Zonal Office, Central Pollution Control Board.

FORM 1(bb)

[See rules 4(2), 8(2)(a), 13(2) (iii) and 13(4)(ii)]

FORMAT FOR GRANTING AUTHORISATION FOR GENERATION OR STORAGE OR TREATMENT OR REFURBISHING OR DISPOSAL OF E-WASTE BY MANUFACTURER OR REFURBISHER

Ref: Your application for Grant of Authorisation

1. (a) Authorisation no. .... and (b) date of issue ………………………….

2. …….………………………of……………………………is hereby granted an authorisation for generation, storage, treatment, disposal of e-waste on the premises situated at………………………………………… for the following:

a. quantity of e-waste;
b. nature of e-waste.

3. The authorisation shall be valid for a period from ……… to …………

4. The e-waste mentioned above shall be treated/ disposed off in a manner .... at
....

5. The authorisation is subject to the conditions stated below and such conditions as may be specified in the rules for the time being in force under the Environment (Protection) Act, 1986.

Signature -------------------------

Designation ---------------------- Date: --------------------

Terms and conditions of authorisation

1. The authorisation shall comply with the provisions of the Environment (Protection) Act, 1986, and the rules made thereunder.
2. The authorisation or its renewal shall be produced for inspection at the request of an officer authorized by the concerned State Pollution Control Board.
3. Any unauthorised change in personnel, equipment as working conditions as mentioned in the application by the person authorized shall constitute a breach of his authorisation.
4. It is the duty of the authorised person to take prior permission of the concerned State Pollution Control Board to close down the operations.
5. An application for the renewal of an authorisation shall be made as laid down in sub-rule (vi) of rule 13(2).

FORM-2

[See rules 4(4), 5(4), 6(5), 8(7), 9(2), 10(7), 11(8), 13 (1) (xi), 13(2)(v), 13(3)(vii) and 13 (4)(v)]

FORM FOR MAINTAINING RECORDS OF E-WASTE HANDLED OR GENERATED

Generated Quantity in Metric Tonnes (MT) per year

1.	Name & Address: Producer or Manufacturer or Refurbisher or Dismantler or Recycler or Bulk Consumer*		
2.	Date of Issue of Extended Producer Responsibility Authorisation*/ Authorisation*		
3.	Validity of Extended Producer Responsibility Authorisation*/ Authorisation*		
4.	Types & Quantity of ewaste handled or generated**	Category	Quantity
		Item Description	
5.	Types & Quantity of e-waste stored	Category	Quantity
		Item Description	
6.	Types & Quantity of e-waste sent to collection centre authorised by producer/ dismantler/recycler / refurbisher or authorised dismantler/recycler or refurbisher**	Category	Quantity
		Item Description	
7.	Types & Quantity of e-waste transported*	Category	Quantity
		Quantity	
	Name, address and contact details of the destination		
8.	Types & Quantity of e-waste refurbished*	Category	Quantity
		Item Description	
	Name, address and contact details of the destination of refurbished materials		
9.	Types & Quantity of e-waste dismantled*	Category	Quantity
		Item Description	
	Name, address and contact details of the destination		
10.	Types & Quantity of e-waste recycled*	Category	Quantity
		Item Description	

	Types & Quantity of materials recovered	Quantity	
	Name, address and contact details of the destination		
11.	Types & Quantity of ewaste sent to recyclers by dismantlers	Category	Quantity
		Item Description	
	Name, address and contact details of the destination		
12.	Types & Quantity of other waste sent to respective recyclers by dismantlers/recyclers of e-waste	Category	Quantity
		Item Description	
	Name, address and contact details of the destination		
13.	Types & Quantity of e-waste treated & disposed	Category	Quantity
		Item Description	
	Name, address and contact details of the destination		

Note:-

(1) * Strike off whichever is not applicable

(2) Provide any other information as stipulated in the conditions to the authoriser

(3) ** For producers this information has to be provided state-wise

FORM-3

[See rules 4(5), 5(5), 8(6), 9(4), 10(8), 11(9), 13 (1) (xi), 13(2)(v), 13(3)(vii) and 13(4)(v)]

FORM FOR FILING ANNUAL RETURNS

[To be submitted by producer or manufacturer or refurbisher or dismantler or recycler by 30th day of June following the financial year to which that return relates].

Quantity in Metric Tonnes (MT) and numbers

1	Name and address of the producer or manufacturer or refurbisher or dismantler or recycler			
2	Name of the authorised person and complete address with telephone and fax numbers and e-mail address			
3	Total quantity of e-waste collected or channelised to recyclers or dismantlers for processing during the year for each category of electrical and electronic equipment listed in the Schedule I (Attach list) by PRODUCERS			
	Details of the above	TYPE	QUANTITY	No.
3(A)*	BULK CONSUMERS: Quantity of ewaste			
3(B)*	REFURBISHERS: Quantity of e-waste:			
3(C)*	DISMANTLERS: i Quantity of e-waste processed (Code wise); ii. Details of materials or components recovered and sold; iii. Quantity of e-waste sent to recycler; iv. Residual quantity of e-waste sent to Treatment, Storage and Disposal Facility.			
3(D)*	RECYCLERS: i. Quantity of e-waste processed (Code wise); ii. Details of materials recovered and sold in the market; iii. Details of residue sent to Treatment, Storage and Disposal Facility.			
4	Name and full address of the destination with respect to 3(A)-3(D) above			
5	Type and quantity of materials segregated or recovered from e-waste of different codes as applicable to 3(A)-3(D)	Type	Quantity	

✔ Enclose the list of recyclers to whom e-waste have been sent for recycling.

Place__________________

Date___________________ **Signature of the authorised person**

Note:-

(1) * Strike off whichever is not applicable

(2) Provide any other information as stipulated in the conditions to the authoriser

(3) In case filing on behalf of multiple regional offices, Bulk Consumers and Producers need to add extra rows to 1 & 3(A) with respect to each office.

FORM-4

[See rules 13(3)(i) and 13(3)(vi)]

APPLICATION FORM FOR AUTHORISATION OF FACILITIES POSSESSING ENVIRONMENTALLY SOUND MANAGEMENT PRACTICE FOR DISMANTLING OR RECYCLING OF E-WASTE

(To be submitted in triplicate)

<table>
<tr><td>1.</td><td>Name and Address of the unit</td><td colspan="3"></td></tr>
<tr><td>2.</td><td>Contact person with designation, Tel./Fax</td><td colspan="3"></td></tr>
<tr><td>3.</td><td>Date of Commissioning</td><td colspan="3"></td></tr>
<tr><td>4.</td><td>No.of workers (including contract labour)</td><td colspan="3"></td></tr>
<tr><td>5.</td><td>Consents Validity</td><td colspan="3">a. Water (Prevention and Control of Pollution) Act, 1974;
Valid up to __________________ b. Air (Prevention and Control of Pollution) Act, 1981;
Valid up to__________________</td></tr>
<tr><td>6.</td><td>Validity of current authorisation if any</td><td colspan="3">e-waste (Management & Handling) Rules, 2011;
Valid up to ______________</td></tr>
<tr><td>7.</td><td>Dismantling or Recycling Process</td><td colspan="3">Please attach complete details</td></tr>
<tr><td rowspan="3">8.</td><td rowspan="3">Installed capacity in MT/year</td><td>Products</td><td colspan="2">Installed capacity (MTA)</td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td rowspan="4">9.</td><td rowspan="4">E-waste processed during last three years</td><td>Year</td><td>Product</td><td>Quantity</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td rowspan="2">10.</td><td>Waste Management:</td><td colspan="3"></td></tr>
<tr><td>a. Waste generation in processing e-waste</td><td colspan="3">Please provide details material wise</td></tr>
</table>

	b. Provide details of disposal of residue.	Please provide details
	c. Name of Treatment Storage and Disposal Facility utilized for	
11.	Details of e-waste proposed to be procured from re-processing	Please provide details
12.	Occupational safety and health aspects	Please provide details
13.	Details of Facilities for dismantling both manual as well as mechanised:	
14.	Copy of agreement with Collection Centre	
15.	Copy agreement with Producer	
16.	Details of storage for dismantled e-waste	
17.	Copy of agreement with Recycler	
18.	Details of Facilities for Recycling	
19.	Copy of agreement with Collection Centre	
20.	Copy agreement with Producer	
21.	Details of storage for raw materials and recovered materials	

II. In case of renewal of authorisation, previous registration or authorisation no. and date

I hereby declare that the above statements or information are true and correct to the best of my knowledge and belief.

Signature

Place:_______________ Name:__________________________

Date:_______________ Designation:__________________________

Form-5

[See rule 18 (1)]

FORM FOR ANNUAL REPORT TO BE SUBMITTED BY THE STATE POLLUTION CONTROL BOARD TO THE CENTRAL POLLUTION CONTROL BOARD

To,

The Chairman,

Central Pollution Control Board,

(Ministry of Environment And Forests)

Government Of India, 'Parivesh Bhawan', East Arjun Nagar,
Delhi- 110 0032

1.	Number of authorised manufacturer, refurbisher, collection centre, dismantler and recycler for management of e-waste in the State or Union territory under these rules	:	
2.	Categories of waste collected along with their quantities on a monthly average basis:	:	Please attach as Annexure-I
3.	A Summary Statement code-wise of e-waste collected	:	Please attach as Annexure-II
4.	Details of material recovered from recycling of e-waste	:	
5.	Quantity of CFL received at Treatment, Storage and Disposal Facility	:	
6.	The above report is for the period from ……………to ………………………………		

Place: __________________

Date: _________________

Chairman or the Member Secretary
State Pollution Control Board

Form-6

[See rule 19]

E-WASTE MANIFEST

1.	Sender's name and mailing address (including Phone No.) :	
2.	Sender's authorisation No, if applicable. :	
3.	Manifest Document No. :	
4.	Transporter's name and address : (including Phone No.)	
5.	Type of vehicle :	(Truck or Tanker or Special Vehicle)
6.	Transporter/s registration No. :	
7.	Vehicle registration No. :	
8.	Receiver's name & address :	
9.	Receiver's authorisation No, if applicable. :	
10.	Description of E-Waste (Item, Weight/ Numbers) :	
11.	Name and stamp of Sender* (Manufacturer or Producer or Bulk Consumer or Collection Centre or Refurbisher or Dismantler): Signature: Month Day Year	
12.	Transporter acknowledgement of receipt of E-Wastes	
	Name and stamp: Signature: Month Day Year	
13.	Receiver* (Collection Centre or Refurbisher or Dismantler or Recycler) certification of receipt of E-waste	
	Name and stamp: Signature: Month Day Year	

* As applicable

Note:-

Copy number with colour code (1)	Purpose (2)
Copy 1 (Yellow)	To be retained by the sender after taking signature on it from the transporter and other three copies will be carried by transporter.
Copy 2 (Pink)	To be retained by the receiver after signature of the transporter.
Copy 3 (Orange)	To be retained by the transporter after taking signature of the receiver.
Copy 4 (Green)	To be returned by the receiver with his/her signature to the sender

FORM 7

[See rule 22]

APPLICATION FOR FILING APPEAL AGAINST THE ORDER PASSED BY CENTRAL POLLUTION CONTROL BOARD/STATE POLLUTION CONTROL BOARD

1. Name and address of the person making the appeal :
2. Number, date of order and address of the authority the to which passed the order, against which appeal is : (certified copy of order be attached)
3. Ground on which the appeal is being made :
4. Relief sought for :
5. List of enclosures other than the order referred in point 2 against which the appeal is being filed. :

Signature…………………

Name and address…………

Place:

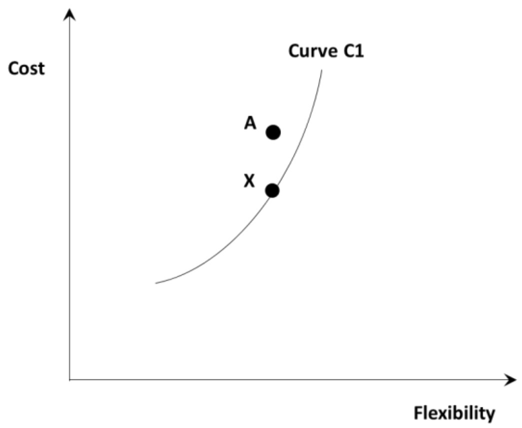
Date:

Bishwanath Sinha
Joint Secretary to Government of India
(F No. 12-6/2013-HSMD)

Appendix 8: Explaining alignment of Informal Processors' operational configuration

Informal Processors excel at all the four dimensions/parameters i.e. low cost, high flexibility, high quality, quick turnaround. Essentially, the discussion then moves to trade-offs theory (i.e. trade-offs among the various dimensions of operational configuration) and the concept of performance frontier. There are two views suggested by OM theory[64]: (1) Static view: This view is at a particular point in time when the technology/processes are given/stable and do not change. In the static view, there are cases where there is a trade-off, and there are cases without trade-offs. In this scenario, the inefficient firms do not have trade-offs and only the efficient firms have trade-offs. Efficient firms lie in the performance frontier. (2) Dynamic view: This view is over a period of time when there is a change in technology or process. This leads to a shift in the performance frontier and trade-off levels reach a new equilibrium. We explain these two views as follows. The static view is illustrated in **Error! Reference source not found.**.

Figure 37: Performance frontier (static view)

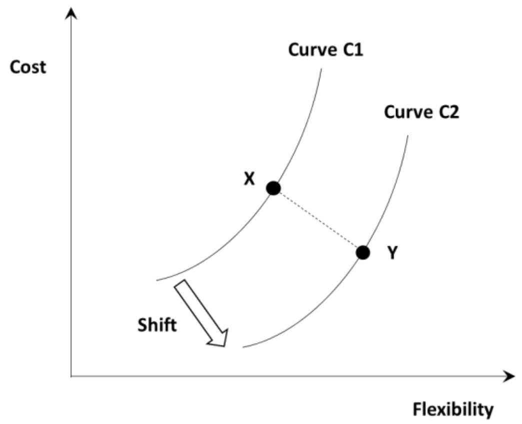


As flexibility increases, cost increases exponentially i.e. to deliver higher flexibility, the firm needs to incur higher cost; if the firm wants to reduce the cost, its flexibility will be lost. This curve is called as the performance frontier. If the firm is efficient in trading off between flexibility and cost (i.e. firm is at position X), it can move along (slide up or down) the performance frontier i.e. efficient firms lie on the performance frontier. Inefficient firms lie on the upper side of the curve (firm at position A) i.e. those firms would incur higher cost for the same level of flexibility provided by efficient firms. In essence, the performance frontier says

[64] The following explanation is inferred and synthesized from Schmenner & Swink (1998), Samuelson & Nordhaus (2009). The concept of 'performance frontier' used by OM scholars, originated from Paul Samuelson's work on 'production frontier', that was published in his seminal 1947 book titled *Foundations of Economic Analysis*.

that for a given flexibility, there is a lower cost possible. In the new scenario (dynamic view), the cost can come down for a given flexibility or for the same cost the firm would be able to deliver higher flexibility. So, when a technology or process change happens, the performance frontier shifts to down and right (curve C2). This dynamic view is illustrated in **Error! Reference source not found.**.

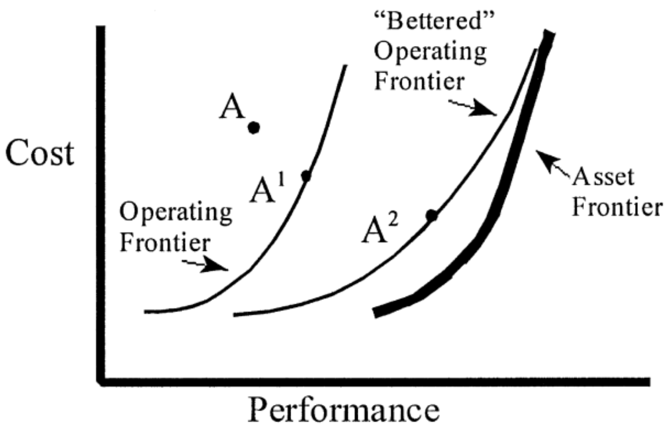
Figure 38: Performance frontier (dynamic view)



Before the technology or process change happened, the firm was in position X in the curve C1. From X, the firm can move along the curve i.e. it could slide up (higher flexibility, higher cost) or it could slide down (lower cost, lower flexibility). Due to the change in technology or process, the curve shifted from C1 to C2 i.e. a shift in performance frontier. Now, the firm is in position Y and can deliver higher flexibility at lower cost. Through this explanation, we show that low cost and high flexibility can be achieved when the performance frontier shifts.
This logic considers only two dimensions (cost, flexibility) for the purpose of illustration/explanation. The same logic is applicable for additional dimensions (quality, turnaround time). When all these four dimensions (cost, flexibility, quality, turnaround time) are analyzed, instead of a two-dimensional plane (as illustrated in figures 1 and 2), we will have a hyperplane with multiple dimensions.

This explanation shows that a firm can compete on more than 2 dimensions/parameters and this is consistent with OM theory. Schmenner & Swink (1998) illustrated this using the following figure and explanation.

Figure 39: Performance frontier (Schmenner & Swink, 1998)



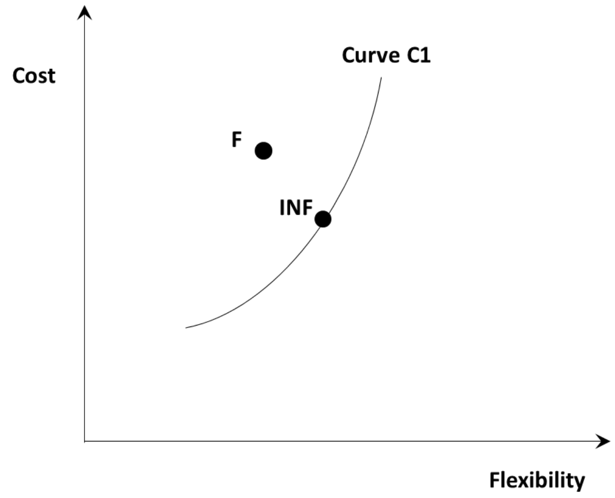
(Courtesy: Schmenner & Swink (1998))

Schmenner & Swink (1998) divided performance frontier into two components: asset frontier and operating frontier. Removing inefficiencies in the production processes, move a firm from position A to position A^1. Changing the operating policies (for example introducing Just-in-time, total quality management, etc.) move a firm from position A^1 to A^2. It is to be noted that asset frontier can itself be improved through radical technology upgrades in the physical plant using large capital investments. Schmenner & Swink (1998) said:

> "The law of trade-offs states that no single plant can provide superior performance in all dimensions simultaneously. We would expect to find support for this law if all competitors use similar technologies and are operating near the asset frontier. If all plants are far from the asset frontier, however, one plant can simultaneously provide higher levels of product quality, flexibility, and delivery at a lower manufactured cost if, through betterment, its management approaches create an operating frontier which is superior to its competitors."

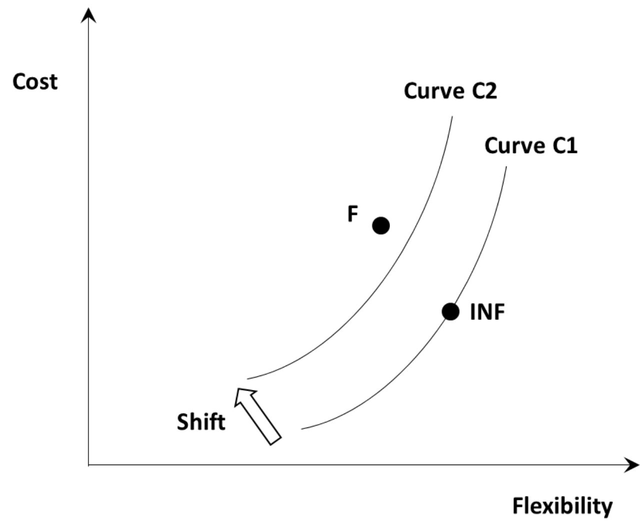
Now, we apply this concept of performance frontier in the e-waste processing industry. This is illustrated in the figure below.

Figure 40: Performance frontier (e-waste industry)



Curve C1 denotes the performance frontier for this industry. The Formal Processors (denoted by F), who operate inefficiently, would lie above the curve C1. But, the Informal Processors (denoted by INF) lie on curve C1. INF is able to offer higher flexibility (ability to work on heterogeneous products) at lower cost when compared to F. This is because Informal Processors naturally operate in a low-cost environment (revealed through P1, P7a in Chapter 4) and skilled in manual disassembly on heterogeneous products (revealed through P14c, Theme 4 in Chapter 5). A take-back legislation when enforced, *intends* to shift the curve C1 to the up and left (C1 to C2). The intention of legislation is to protect environment. But, the impact of legislation made it difficult for INF to lie in curve C1 and easy for F to reach C2. This is illustrated in the following figure.

Figure 41: Performance frontier shift (e-waste industry)



In summary, legislation helped establish an efficiency frontier that is superior and includes the environmental cost. While it easy for F to reach this frontier (owing to its ‘formal processes’ that factors the environmental costs), INF has to face extreme challenges/difficulties to reach this frontier. This is because INF would have to incur the environmental costs, by adopting ‘formal processes’.